A National Program of Research for

NEW CROPS AND MINOR OILSEEDS

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

March 1969

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PREFACE

Background

The long-range study, "A National Program of Research for Agriculture," conducted by a joint USDA-SAES Task Force, was published in October 1966. The second recommendation of the study called for a more systematic and continuing mechanism that would facilitate joint research program planning, evaluation, and coordination. The Agricultural Research Planning Committee at its July and December 1966 meetings recommended the establishment of task forces to develop coordinated State-Federal plans for specified areas of research. Subsequently, thirty-two task forces were established of which this is one.

Authority

The Joint Task Force on Other Oilseeds, Miscellaneous, and New Crops (New Crops and Minor Oilseeds) was appointed jointly by G. L. Mehren, Assistant Secretary of Agriculture, and A. E. Hazen, Chairman of the Experiment Station Committee on Organization and Policy, and announced on April 8, 1968.

Membership

USDA -- J. L. Creech, Chief, New Crops Research Branch, Crops Research Division, Agricultural Research Service - Co-Chairman
B. A. App, Assistant Chief, Grain and Forage Branch, Entomology Research Division, ARS
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W. R. Langford, Regional Coordinator, S-9, Regional Plant Introduction Station, Experiment, Georgia 30212
R. J. Snetsinger, Associate Professor, Mushroom and Ornamental Insects, Pennsylvania State University, University Park, Pennsylvania 16802

Staff Secretary: Max Hinds, Research Program Development and Evaluation Staff

Assignment

The assignment to this task force was to consider "other oilseeds, miscellaneous, and new crops" not assigned to other task forces dealing with crops. Eleven other task forces that dealt with crops and plants were:

Forage Range and Pasture	Soybeans	Cotton
Wheat and Other Small Grains	Peanuts	
Corn and Grain Sorghum	Tobacco	
Vegetables	Rice	
Fruit	Sugar	

This task force considered 35 different crops or types of plants under three categories:

Established crops	9
Developing crops	7
New crops	19

The term "other oilseeds" as part of the title had meaning within the context of all the task forces and their assignments but for a separate task force report it was inadequate. The title, "New Crops and Minor Oilseeds" was finally chosen for this report, recognizing that it too had shortcomings, especially with reference to mushrooms, mint, hops, and guar. It was decided to discuss mushrooms in a separate section of the report because of the many differences between them and other crops considered by this task force. The reasons become apparent upon reading that part of the report. The applicable research problem areas taken from "A National Program of Research for Agriculture" are shown in the Table of Contents.

SUMMARY OF KEY ITEMS

In order to permit the reviewer to reach key items rapidly, a short summary in the form of guide sentences has been prepared.

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C. Product Development and Quality

I. INTRODUCTION

The Task Force considered that its objective was to bring together a plan that would guide research administrators through 1977 for the efficient use of scientific man-power and distribution of research responsibilities for the assigned crops. These agronomic crops are characterized by comparatively limited acreage (except flax, 2.7 million acres), but may serve in the future as a means of diversifying agriculture to meet the needs of the small farmer as well as the large agricultural operations.

On the other hand, because we still import over a billion pounds of vegetable oils annually and our needs for unique industrial end-products and paper pulp are increasing, any one of these potential new crops can develop to major proportions. As a consequence, projected research must be flexible to allow for shifts in emphasis.

A. Importance and Potentials of New and Miscellaneous Crops

A productive agriculture and industry based on plant products is wholly dependent on plant variability. The development of new crops as well as the expansion of existing crops relies on an increasing base of germ plasm for insect and disease resistance, improved adaptation and yield, diversified end-products, and economic acceptance.

Of the crops and crop products which can be produced in the United States (including Puerto Rico) and are under some degree of research effort, the following are examples of import value (1967): black pepper - $10 million; bamboo - $2 million; castor oil - $12 million; guar - $3 million; hops - $7 million; mushrooms - $10 million; pistachio nuts - $10 million; plantago - $1 million; seedoils (soy, cotton, sunflower, rape) - $3 million; sesame - $5 million; steroids - $10 million; rotenoids - $1.5 million; tanning agents - $9 million; tung - $2.3 million; vegetable gums and mucilages - $4.2 million. In aggregate, these crops represent a total import value of $90 million.

Many of these crops are particularly suited to fringe areas of agriculture or have cultural requirements suited to small farm operations. To illustrate the potential value of new crops in diversifying agriculture, _Tephrosia_ as a domestic source of rotenoid resins is presented in Appendix I. This particular illustration is of significance because _Tephrosia_ is most promising in the depressed agricultural areas of the southeast. In addition, it is an opportunity to increase operation time on costly extraction equipment that is presently used at less than full capacity by industry. Furthermore, certain new crops such as unique oilseeds and annual pulps offer agricultural opportunities of a magnitude that could rank them as major crops.

B. Basic Concepts and Historical Trends

A broad array of crops has been covered in this Task Force assignment. These crops are widely dispersed in relation to agronomic adaptation and economic impact.

For purposes of clarifying the relative position of the crop groups, we determined three broad categories based on relative crop status and potentials for expansion. These are as follows:

1. Established Crops - those which are apparently at their maximum acreage despite imports or for which expansion has been projected to be small under existing conditions.

2. Developing Crops - those in agriculture but still to reach maximum production and utilization and for which there are considerable imports.

3. New Crops - those not in agriculture but with end-products that indicate considerable crop potential. These are evolving largely through crops/utilization inter-disciplinary research.

Frame of Reference: The successful efforts to efficiently expand crop production has been a mark of American agriculture since Colonial times. Being a country with practically no native crop species, the opportunities to introduce and develop new crops for food, feed, fiber, and other purposes have challenged scientists and farmers alike for years. Each era of industrial progress has provided us with additional agricultural opportunities and has resulted in a continuously diversified agriculture.

In 1957, A Task Force on New and Special Crops reported their findings to a Presidential Commission on Increased Industrial Use of Agricultural Products. That Task Force described 36 new crops as promising and requiring additional research effort. Since that report, one crop, Safflower, has more than tripled its acreage and two entirely new crops, Crambe (oilseed) and Dioscorea (cortisone precursor), have gone into minor commercial production. Others, such as kenaf (paper pulp) and Vernonia (oilseed) are on the brink of commercialization. There is, additionally, that group of small but steady crops which because of unique cultural requirements or fixed markets remains somewhat static. Nevertheless they are essential to our economy and provide a means of agricultural livelihood.

The Plant Science and Entomology, the Utilization Research and Development Advisory Committee, and the Oilseeds Research Advisory Committees repeatedly have made the need for continued research on these "other oilseeds" and new crops one of their recommendations.

The Task Force is aware that specific encouragement for any one of these crops is required until the crop gains a market potential and that assisting them through the "awkward stage" is a USDA-SAES joint responsibility. Allowance for the variability of the rate at which any new crop candidate progresses towards production requires that scientific man-power and resources remain flexible.

Situation: The Task Force recognizes that no set pattern of research could fit all situations envisioned for a miscellany of crops. Established Crops have research needs that include RPA's similar to major crops. The Developing Crops have lesser need for RPA's reflective of advanced cultural practices, such as RPA's 209, 308, 309, 501, and 504. In the case of New Crops, those RPA's dealing with Biological Efficiency, Utilization and Control of Insects and Diseases have the most immediate application. More extensive research must be held in abeyance until promising new crops are under research consideration by commodity-oriented branches or departments.

Private industry has made contributions to the new crops research effort through their own programs and also in the form of recommendations to the USDA. Recently, a conference sponsored by a committee of The Technical Association of the Pulp and Paper Industry resolved that kenaf is a new raw material for the pulp and paper industry that has definite agricultural, technological, and economic potential for the development of a crop of importance for the United States and submitted a resolution to the USDA recommending expanded research on this crop.

Private industry is alert to the need to undertake production-scale efforts with entirely new crops. Crambe, a promising new oilseed, was planted in Louisiana on between 5,000 to 6,000 acres in alternation with soybeans after the fall soybean harvest in 1967-68.

Further, and important, encouragement to the growing of selected ones of these emerging crops is the fact that they are authorized to be grown on acreage diverted from feed grain and cotton. The qualifying crops are castorbeans, flaxseed, guar, crambe, psyllium (plantago), mustard, sesame, sunflower, and safflower. Except for the last two, there is an incentive of half of the diversion payment if farmers grow any of these alternate crops.

CROPS AND CROP PRODUCTS CONSIDERED, BY CATEGORIES

I. Established Crops

A. Oilseeds

1. Flax
2. Safflower
3. Sunflower
4. Castorbeans
5. Tung

B. Foods and Food Supplements

1. Mushrooms (separate section)
2. Mint
3. Hops

C. Industrial or Special Use Crops

1. Guar

II. Developing Crops

A. Oilseeds

1. Crambe
2. Rape
3. Mustard
4. Sesame

B. Food and Special Use Crops

1. Sesame
2. Plantago
3. Dioscorea

III. New Crops

A. Oilseeds

1. Vernonia
2. Euphorbia
3. Fennel
4. Lesquerella
5. Limnanthes
6. Briza

B. Foods and Food Supplements, Special Crops

1. Exotic vegetables
2. Subtropical fruit and root crops
3. Essential oils, beverages, and drug crops
4. New protein supplements
5. Enzymes
6. Condiments and food additives

C. Gums, Resins, Starches

1. Crotalaria
2. Cassia
3. Saponaria

D. Annual Pulp Fibers

1. Kenaf
2. Crotalaria
3. Sorghum

E. Insecticides

1. Tephrosia

The Task Force, in reviewing group III. B., recognized that these are likely to be considered by the Task Forces dealing with fruits and vegetables and that certain others do not require man-power in-puts at this time. However, we believe that it is important to record that they are worthy of continual review in case there becomes a prospect for their use in agriculture.

Mushrooms are unique and are reported as a separate activity. In many parts of the world they are regarded as a horticultural crop.

C. Research Perspective and Comments

The inventory of agricultural research indicated a total 1966 research effort of 136 SMY's and a projected 1977 SMY requirement of 195 in order to accomplish the objectives established for other oilseeds, miscellaneous, and new crops. Of this actual and projected effort, the greatest in-puts are in the areas of utilization (1966 - 57 SMY's to 1977 - 66 SMY's) and production (1966 - 49 SMY's to 1977 - 76 SMY's).

This is brought about by the fact that future prospects for new crops lie primarily in discovering unique end products in conjunction with estimates and evaluations of the agronomic potentials. Although the same is true to a lesser extent for the developing crops, in all of the assigned crop groups less is known about their requirements for protection and marketing complexities than for any other task force responsibilities. Furthermore the limited economic impact does not warrant a greater investment of SMY's in production and marketing at this time.

Until unit costs of production of minor established crops can be reduced to put them in a competitive position or this factor is equalized by an increased demand for the product through discovery of new end-uses, they will be grown on limited acreage.

The Task Force generally concurs in the recommendations of the long range study which indicates that the utilization aspects of this program are a USDA responsibility through its Utilization Research and Development Divisions. However, the projected SMY's recommended by the LRS of 66 SMy's for 1977 fall short of the indicated needs demonstrated by the range of potential new products. The Task Force has recommended 120 SMY's by 1977 for Utilization RPA's.

The protection, production, and marketing aspects may be either Federal or State based on agronomic requirements, distribution of expertise to meet the specific problems, and allowance for flexibility to shift man-power to those crops which show most promise.

In the allocation of SMY's the Task Force attempted to allocate SMY's directly to subcategories of each RPA but did not identify these sub-units with SAES or USDA effort.

JOINT TASK FORCE ON NEW CROPS AND MINOR OILSEEDS
Summary of Inventory and Recommended SMY's 1/

	Research Problem Area	1966 2/ TOTAL	1966 2/ USDA	1966 2/ SAES	1977 3/ TOTAL	1977 3/ USDA	1977 3/ SAES
207	Control of Insect Pests	5	1	4	9(10)	1(2)	8
208	Control of Diseases	19	12	7	36(26)	24(17)	12(9)
209	Control of Weeds, etc.	3	1	2	5(8)	1(4)	4
	Subtotal - Protection	27	14	13	50(44)	26(23)	24(21)
307	Biological Efficiency	45	16	29	70	23	47
308	Mechanization	0	4/	0	0	4/	0
309	Systems Analysis	0	5/	0	0	5/	0
405	Consumer Acceptability	4	3	1	6	4	2
	Subtotal - Production	49	19	30	76	27	49
406	Food Products	6	0	6	9(17)	3(11)	6
407	Feed & Nonfood Products	51	49	2	57(103)	55(95)	2(8)
	Subtotal - Utilization	57	49	8	66(120)	58(106)	8(14)
408	Market Quality	1	1	0	1(4)	0(2)	1(2)
501	Grades and Standards	0	0 6/	0	0(7)	0(3) 6/	0(4)
504	Market Efficiency	2	0	2	2(8)	2(4)	0(4)
	Subtotal - Marketing	3	1	2	3(19)	2(9)	1(10)
	GRAND TOTAL	136	83	53	195(259)	113(165)	82(94)

1/ Recommendations for Mushrooms not included, see page 89.
2/ Inventory of Agricultural Research, Volume I, Table I, June 1967.
3/ A joint committee representing the Experiment Station Committee on Organization and Policy, and the USDA, reviewed manpower allocations and recommended the SMY's shown. The changes recommended by the Task Force are shown in parentheses.
4/ The 1966 Inventory shows a total research program in RPA 308 of 100 SMY's -- 40 USDA, 60 SAES. The joint committee recommended 59 additional SMY's for 1977 -- 40 SAES, 19 USDA, for mechanization of all field crops but did not allocate to specific crops.
5/ The 1966 adjusted base shows a total research program in RPA 309 of 20 SMY's -- 12 SAES, 8 USDA. The joint committee recommended 47 additional SMY's (17 USDA, 30 SAES) for 1977 for all field crops - not allocated by crop.
6/ The 1966 inventory shows 33 SMY's devoted to RPA 501, 17 SAES, 16 USDA. Thirty SMY's have been allocated to other commodities. Any work pertaining to new crops and minor oilseeds would be conducted by the remaining 3 unallocated SMY's. No increase was projected for the unallocated SMY's.

II. RESEARCH GOALS AND PROBLEM AREAS

A. Protection - Goal II

In the "National Program of Research for Agriculture," the objective under Goal II is to protect forests, crops, and livestock from natural and artificial hazards. With reference to crops, the program would involve seeking basic information on insects, diseases, weeds, and environmental hazards that cause losses in crops and to develop effective economic means for their control or elimination.

This objective was broken down fruther into 14 research problem areas of which three were applicable to the crops considered by this task force. The three are: RPA 207, Control of Insect Pests of Field Crops; RPA 208, Control of Diseases of Field Crops; and RPA 209, Control of Weeds and Other Hazards to Field Crops.

Many species of insects, numerous plant diseases, and a variety of weeds cause losses to minor oilseeds, miscellaneous and new crops. For some of these crops that are now being grown commercially on a limited acreage, some knowledge of the loss due to these factors is available but for crops being developed and for new potential crops such information is often very limited or lacking entirely. This information is necessary for the profitable production of these crops. Because of the large number of crops involved and the variety of pests, it is almost impossible to assign SMY's to individual crops or problems. To do so it would be necessary to assign fractional man-years to many problems. Because of this, RPA 207, 208, and 209 are are given broad coverage and the SMY's assigned to the overall problem are noted under each area. The total research effort is shown in the Summary Table, page 6.

CONTROL OF INSECT PESTS IN ESTABLISHED CROPS

RPA 207A

Situation: The established oilseed crops, flax, safflower, sunflower, castorbean, and tung, and the miscellaneous crops, hops, mint, and guar, are attacked and damaged by more than 30 species of insects. Only limited knowledge is available on the biology and importance of some of these pests and specific control methods for many of them have not been developed. In order to devise effective, adequate control methods, data on development, seasonal history, abundance, host range, and related biological, and physiological factors are essential.

Objective: To determine the life history, distribution, abundance of the different species; determine the threshold of economic damage; and develop cultural or other methods of control.

Research Approaches:

1. Field collections of insects will be made to determine the species present on the different crops and their seasonal abundance.

2. Field observations and laboratory and field cage studies will be used to determine the biology of the major species and the level of abundance necessary to cause economic losses.

3. Field observations to determine the abundance and kind of insect pollinators and their influence on seed production for those crops where insect pollination is essential.

4. Conduct laboratory and field tests with different insecticides in order to develop safe chemical control methods. Samples of the different crops and crop products will be analyzed for insecticide residues following treatment with promising materials.

5. Screen varieties and selections of the different crops to locate sources of germ plasm showing resistance to insects that might be used by plant breeders to develop insect resistant varieties.

6. Search for parasites, predators, and pathogens of the major pests of these crops and explore the possibility of mass rearing and releasing any that show promise.

Potential Benefits: Reduce cost of production and increase yield and quality. Reduce hazards of insecticide residues. Allow expansion of acreage devoted to some of these crops. Losses caused by insects to many of these crops are not known but it has been estimated that insect damage to hops and mint alone amounts to several million annually. Adequate insect control methods could eliminate much of this loss, and also permit the economic production of some crops now grown on a limited scale.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
4	5

CONTROL OF INSECT PESTS IN DEVELOPING CROPS

RPA 207B

Situation: A limited amount of information is available on the insect pests of sesame but those attacking crambe, mustard, rape, plantago, and dioscorea have received little study. In order that these potentially valuable crops can be developed into economically profitable crops, it will be necessary to have data on the insect species present, their economic damage and safe effective methods of control.

Objective: To determine the species of insects attacking sesame, crambe, mustard, rape, plantago and dioscorea, their potential for economic damage, and to devise safe effective control methods.

Research Approaches:

1. Surveys will be made in the limited plantings of these crops to determine the species of insects present.

2. Field observations and cage studies will be made to determine the type and extent of damage caused by the most abundant species.

3. Studies will be made on the biology, development, host plants, and seasonal abundance of the major species.

4. Field observations will be made to determine the insect pollinators present particularly for such crops as mustard and rape where insect pollination is essential, and for sesame where it is beneficial.

5. Laboratory and field tests will be made with various insecticides to develop chemical controls for the most important pests that will not be detrimental to beneficial insects or leave hazardous residues on or in the crop or crop products.

6. Search for parasites, predators, or insect pathogens that might be used to develop noninsecticidal methods of control.

Potential Benefits: A knowledge of the biology and control methods for the major insect pests of crambe, mustard, rape, plantago, and dioscorea will contribute substantially to the economics of producing them. At the present stage of development of these crops, it is not possible to estimate the potential dollar losses that insects might cause. However, as has been demonstrated with other introduced crops, it will probably not be possible to profitably produce those crops without controlling the insects.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
1	2

CONTROL OF INSECT PESTS IN NEW CROPS

RPA 207C

Situation: Every year numerous new crops and new varieties of crops are introduced into the United States from many areas of the world. Extensive precautions are taken to see that the insect pests of these crops in their native habitats are not introduced with them. However, in most cases there is no information on the potential damage that might be caused by insects and related pests present in their new environment. Before any of these new crops is developed to the point of commercial production some knowledge of their insect enemies, their potential damage, and possible methods to combat them should be obtained.

Objective: To study the reactions of new plant introductions to attack by insects, to determine the potential damage of the major pests, and for any commercially promising crops, investigate possible methods to control the insect enemies.

Research Approaches:

1. Through a search of the literature and possibly by observations when the plants are collected in their native habitat, determine the insect species present. Determine if any of these or closely related species occur in the United States that might become pests of the crop.

2. If any experimental plantings of newly introduced crops are made, a careful record will be maintained of the insect species damaging them.

3. For those crops that depend on insects for pollination, determine whether adequate numbers of pollinators are present.

4. Make preliminary evaluations of newly introduced crops to determine whether any of them show resistance to the important insect pests. Such sources of insect-resistant germ plasm may be used by plant breeders to develop improved varieties.

5. When insect pests become sufficiently abundant to cause damage to plantings of newly introduced crops, tests will be made to control them by chemical, cultural, biological, or other methods.

Potential Benefits: The economic potential of newly introduced crops will be more accurately assessed if the insect pests and their damage are known. Improved crop varieties with resistance to insects will reduce hazards and benefit the grower and consumer.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
2	3

CONTROL OF DISEASES IN ESTABLISHED CROPS

RPA 208A

Situation: Numerous disease organisms infect the oilseed crops, flax, safflower, sunflower, castorbean, and tung, and the miscellaneous crops, hops, mint, and guar. These diseases reduce the yield and quality, and may lower the oil content of oilseed crops. Information is available on some of these diseases and some progress has been made controlling them on certain crops. A few varieties with resistance to diseases have been developed. To develop adequate control measures we need much more information on the economic status of these diseases and on their etiology and epiphytology.

Objective: To develop effective control methods for diseases of the oilseed crops, flax, safflower, sunflower, castorbean, and tung, and the miscellaneous crops, hops, mint, and guar.

Research Approaches:

1. Screen varieties and selections of these crops to locate sources of germ plasm resistant to these diseases, that may be used by plant breeders to incorporate disease resistance into varieties with desirable agronomic characteristics.

2. Studies will be made to determine the heritability of disease resistance and any plant factors that may contribute to disease resistance.

3. Studies will be made to determine the feasibility of controlling the diseases by exclusionary methods and by use of suitable fungicides applied to the soil, foliage, or seed.

4. Determine the relationship between the different disease organism and climatic factors.

5. Conduct transmission tests to determine any insects that may prove to be vectors of disease pathogens, and determine the effect of insect control on the incidence of disease.

Potential Benefits: Reduce cost of production and increase yield and quality. The loss to safflower, flax, and castorbean from diseases exceeds $12 million and that to hops and mint is nearly $5 million annually. Effective disease control could reduce much of this loss.

Recommended Research Effort: (SMY's)

	TF Recommendation	
	1972	1977
	9	10

CONTROL OF DISEASES IN DEVELOPING CROPS

RPA 208B

Situation: Although some research has been done on the diseases attacking sesame, there is little information on the control of the disease infecting crambe, mustard, rape, plantago, and dioscorea. To develop these crops to their full economic potential, much more information is needed on the diseases affecting these crops and on methods for their control.

Objective: To determine the economic importance of the diseases attacking crambe, mustard, rape, sesame, plantago, and dioscorea, and to develop methods for their control.

Research Approaches:

1. Determine the relative importance of the various diseases attacking crambe, mustard, rape, sesame, plantago, and dioscorea.

2. Study the etiology and epiphytology of the most important diseases of each crop.

3. Develop control measures based on studies on the disease organisms, emphasizing the least expensive control measures such as seed treatment and crop rotation.

4. Screen varieties and selections of these crops to locate sources of resistant germ plasm, study the heritability of resistance and incorporate disease resistance into new varieties with desirable yield and quality characteristics.

Potential Benefits: Will increase quality and reduce cost of production and allow these crops to be fully developed in the United States. The loss to the limited plantings of sesame alone has been estimated to exceed $120,000 per year. It will be impossible to develop these crops without methods to control diseases.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
5	6

CONTROL OF DISEASES IN NEW CROPS

RPA 208C

Situation: Numerous new crops and new varieties are imported annually into the United States for evaluation for possible production in this country. Often there is no knowledge of the reaction of these crops to diseases under the conditions prevailing in their new environment. A knowledge of the diseases attacking these new crops and of possible methods of control is essential if their production is to become economically feasible.

Objective: To determine the disease organism infecting new crops and investigate possible methods of control.

Research Approaches:

1. All available information on diseases affecting these crops in their native environment would be reviewed in order to determine whether they occur in the United States, and to possibly predict whether closely related diseases might become a problem if these crops are grown in this country.

2. Greenhouse, nursery, and field plantings of new crops will be carefully examined for evidence of disease and attempts made to determine the possible economic significance of any that are found.

3. Plantings will be observed for any evidence of resistance to disease in order to locate sources of germ plasm that may be used by plant breeders to develop resistant varieties.

4. The feasibility of controlling the diseases by exclusionary methods and by the use of fungicides applied to the soil, foliage, or seed will be investigated.

5. Any insects suspected of being vectors of disease pathogens will be studied.

Potential Benefits: Knowledge of diseases affecting new crops will contribute to a more accurate appraisal of their suitability for production in the United States. Since these crops are new introductions in the United States, their economic potential is not fully evaluated. However, the commercial production of them will probably not be possible without a thorough study of plant diseases.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
9	10

CONTROL OF WEEDS IN ESTABLISHED CROPS

RPA 209A

Situation: Studies have been conducted on the importance of weeds in some of these crops, particularly flax, but the effect of weeds on many of them are not fully known. Some of these crops and the products derived from them are in short supply or rely heavily on imports. In order to increase domestic production, the importance of weeds and their effect on the yield or quality of the crop must be determined and methods for their control must be developed.

Objective: To determine the importance of weeds in the production of the oilseed crops, flax, safflower, sunflower, castorbean, and tung, and the miscellaneous crops, hops, mint, and guar, and to develop effective methods for their control.

Research Approaches:

1. Studies will be made to determine the economic importance of specific weed populations in the production of these crops and also on crops that may be grown in rotation with them.

2. The ecology of weed-crop competition will be studied for its role in developing effective control methods.

3. Research will be conducted on various weed control principles to develop cultural, chemical, ecological, biological, or mechanical methods of control or a combination of these methods. Coordination of weed control in oilseed crops with problems in the production of rotational crops will be emphasized.

4. Available herbicides will be evaluated in greenhouse and field tests and under varying environmental conditions to determine their efficiency and economic benefits.

5. For the more promising herbicides, studies will be made to determine methods and rate of application, precise timing of application, and residues that may be in the soil, in or on the crop or crop products.

Potential Benefits: Reduce cost of production, increase yield and quality, and open new areas for production. Effective control could reduce much of the loss of crops caused by weeds.

Recommended Research Effort: (SMY's)

	TF Recommendation	
	1972	1977
	2	3

CONTROL OF WEEDS IN DEVELOPING CROPS

RPA 209B

Situation: Except for sesame on which a limited amount of research has been done, there is very little information available on the effect of weeds on the production of crambe, rape, mustard, plantago, or dioscorea. Information on the weed species involved and their effect on yield and quality of the crop or products derived therefrom is essential to the full economic development of these crops.

Objective: To determine the species of weeds affecting sesame, crambe, rape, mustard, plantago, and dioscorea, their economic significance, and to evaluate various control methods.

Research Approaches:

1. Studies will be made to determine the species of weeds that may affect those crops in areas where they might be grown, and any effect they have on yield and quality as a basis for the need to develop control methods.

2. Evaluate cultural, chemical, biological, and mechanical methods of weed control now used in related agronomic and horticultural crops, and note the response of these developing crops to such practices.

3. Determine the effect of environmental and edaphic factors on the response of these crops to weed control.

4. Add the developing crop species to Federal, State, and industrial programs for evaluating the herbicidal activity of new chemicals.

5. Different herbicides will be tested in order to develop effective chemical control methods that will not result in undesirable residues on the crop or crop products.

Potential Benefits: Will aid substantially in developing these crops to their full economic potential in the United States. Effective weed control would save much of the loss to sesame and will be essential for economic production of the other crops.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
2	3

CONTROL OF WEEDS IN NEW CROPS

RPA 209C

Situation: Whenever new plant varieties are introduced into the United States for evaluation as potential crops, there is usually no information on the effect of weeds on their yield and quality when grown in their new environment. Such data will be most valuable in selecting crops for development and will be necessary for their economic production in the United States.

Objective: To evaluate the effect of weeds on yield and quality of new plant introductions.

Research Approaches:

1. Available information from the locality from which these plants were introduced on the effect of weeds on production will be reviewed.

2. Field plantings of new plant introductions will be made to characterize the effect of native species of weeds on the new plants.

3. Limited selections from weed control practices currently used in related species of established and developing crops will be evaluated for efficacy in plantings of the new introductions.

4. As development of these new crops warrants, studies will be made to develop effective, safe weed control methods by chemical, cultural, biological, mechanical, and combination techniques.

Potential Benefits: A knowledge of the effect of weeds on new plant introductions will permit a more accurate appraisal of the problems affecting the development of these crops in the United States. The potential value of these new crops in the United States is not known, however, weed control will be essential to the full development of any new crops in this country.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
1	2

B. Efficient Production of Farm and Forest Products - Goal III

In the "National Program of Research for Agriculture" the objective under Goal III is the production of an adequate supply of farm and forest products at decreasing real production costs. The objective was further broken down into 16 research problem areas of which three were applicable to new crops, miscellaneous crops, and minor oilseeds: RPA 307, Biological Efficiency of Field Crops; RPA 308, Mechanization of Production of Field Crops; and RPA 309, Systems Analysis in Production of Field Crops.

In addition, Goal IV, "Product Development and Quality," contains a research problem area 405, "Production of Field Crops With Improved Consumer Acceptability," which is applicable to the crops discussed in this section of the report.

Production problems which affect new crops, minor oilseeds, miscellaneous, and other crops are as diverse as those which have been overcome in the successful development of our major crops.

There is need for reduction of unit production costs through more efficient varieties and improved cultural, harvesting, transportation, and processing methods. Gains in new crop areas depend on a joint farm/utilization research input of considerable magnitude before related research in protection and marketing can be implemented. The production research may be State, Federal, or a joint effort. In the last category, there are four Regional Research Projects on New Crops. These have served in the preliminary evaluation program for new crops by providing increased seed and data on the early agronomic potentials and problems for each new crop candidate.

Production research described below is divided into (a) established crops, (b) developing crops, and (c) new crops. Because of the multiplicity of crops considered by this Task Force there is need to maintain flexibility in the research program. It is not possible to predict with certainty which of these crops will move ahead most rapidly.

At such time as any one of these minor crops "emerges" there will need to be a reevaluation of the SMY's which can be assigned to the crop.

BIOLOGICAL EFFICIENCY OF ESTABLISHED CROPS

RPA 307A

Situation:

1. Crops grown on relatively limited acreages.

   a. Limited production because imports largely satisfy present consumer needs (mint, hops, guar).

   b. Unit production costs, with present varieties and practices, are so high as to place product in poor competitive position with similar products (examples: flax, safflower, sunflower, castor beans, tung).

2. Increased production will only result from:

   a. Increased demand for produce resulting from utilization research that creates new uses or more acceptable consumer products.

   b. Reduction of unit production costs resulting from research to substantially increase yield or commodity per unit area, develop more efficient or effective cultural, harvest, transportation, and processing procedures.

Objective:

1. Substantially increase production of desired commodity per unit area.

   a. Develop genotypes that most effectively utilize major growth factors (water, light, energy, and nutrient including CO_2) for maximum production.

Research Approaches:

A. Investigation of genetic and environmental influences on physiological traits that relate to production such as phytosynthetic efficiency.

B. Develop breeding procedures and conduct combining ability tests in order to maximize hybrid vigor for commercial production.

C. Gain information on inheritance of yield potential, quality characters, and pertinent morphological, physiological, and agronomic traits.

Potential Benefits:

A. An increase in yield for unit area of production will result in a comparable increase in net income to the producer.

B. If growers and processors share the benefits from increased production per unit area, the crop commodity will be made more competitive in world markets and with substitute commodities.

C. The likelihood of crop failures will be reduced with the availability of varieties that more efficiently utilize the limiting environmental elements or that possess greater tolerances to suboptimum conditions such as cold, drought, disease, or insect infestation.

Recommended Research Effort: See last paragraph, page 21 and table, page 6.

BIOLOGICAL EFFICIENCY OF DEVELOPING CROPS

RPA 307B

Situation: The general area of adaptation and some of the cultural requirements for these developing crops have been determined. Each has attained crop status, but little expansion of commercial plantings can be anticipated until specific problems of each are solved.

Sesame has been grown commercially in the United States since 1950. Development of non-shattering varieties during the early 1950's encouraged production, and by 1957 there were 15,000 acres of sesame in Texas, New Mexico, and California. Further expansion was deterred by: (1) low seed yields linked genetically with the non-shattering character, and (2) difficulty of extracting seed from non-shattering pods. *Crambe*, *Dioscorea*, and *Plantago* each attained crop status within the last two years. Lack of winter-hardiness is a serious deterrent to further expansion of commercial production of both *Crambe* and *Plantago*. *Crambe* seeds are enclosed by the pericarp which constitutes 25% of the weight of combine-run seed. This increases the cost of transportation and storage and makes the seed less attractive to the processor. *Plantago*, a source of muscilage now imported from India for medicinal purposes, was grown on 1,800 acres in 1966. Further expansion of this crop hinges on development of varieties with more winter-hardiness and better seed retention.

Dioscorea (Mexican yam) is the chief plant source of sapogenins used in the manufacture of cortisone and other steroidal compounds. Early attempts to grow this crop in the United States failed because of difficulties encountered in propagating it. This problem has been solved and there are now 750 acres of *Dioscorea* under cultivation in Puerto Rico. Development of varieties that produce yams near the soil surface and with a higher content of sapogenins would give further impetus to this crop.

Rape and mustard seed oils contain erucic acid for which there is a ready market in the plastics and steel industries. Mustard is now grown as a condiment and rape is cultivated as an oilseed crop in Canada. Varieties that produce more seed per acre and a higher content of erucic acid are needed to further the development of these two crops in the United States.

Objective: Determine specific cultural practices and identify superior germ plasm that will improve the yield and quality of marketable products obtained from these crops.

Research Approaches:

A. Evaluate appropriate cultural practices such as methods and date of seeding, spacing and stand density, and nutrient and water requirements.

B. Evaluate and identify plant characteristics that contribute to higher yields and better quality.

C. Coordinate with disease control studies in 207B, insect control studies in 208B, weed control studies in 209B, and mechanization in 308.

Potential Benefits: Production hazards will be reduced, making these crops more attractive and furthering their establishment as economic crops. Domestic demand for seed oils and other products obtained from these developing corps is now largely supplied by imports or substitutes. If developed to the extent of meeting domestic needs only, these six crops would occupy about 120,000 acres, or perhaps more, annually.

Recommended Research Effort: See last paragraph, page 21 and table, page 6.

BIOLOGICAL EFFICIENCY OF NEW CROPS

RPA 307C

Situation: Results from chemical assays of species in the category of new crops show them to be potential sources of special industrial oils, paper pulp, gums, pesticides and other products of economic importance; but with few exceptions none of them have attained crop status in the United States. Some are recent introductions from the wild; and there is little knowledge of their soil and climatic requirements, potential yield of useful constituent, mode of reproduction, or genetic variability. Some species, such as guava, mango, and papaya, are established crops in foreign countries but they are grown only in small home plantings in this country. Kenaf (*Hibiscus cannabinus*), *Vernonia*, *Lesquerella*, *Tephrosia*, and certain other species have entered the cooperative State-Federal regional evaluation program, but specific soil and climatic requirements of each have not been fully delineated for many of these plants.

Major deterrents to economic production have been established for some species. Inability of *Vernonia* strains now available to retain seed until all are mature prevents this plant from attaining crop status. Yet, there is a ready-market for *Vernonia* seed oil. Low content of rotenoid and lack of a stable seed supply are deterrents to rapid development of *Tephrosia* as a crop. Introduction of superior germ plasm and development of improved varieties are needed for further development of these potential crops.

Objective: Determine the agronomic and horticultural potential of new crop plants and identify deterrents to economic production.

Research Approaches:

1. Regional evaluation of new crop plants under a wide range of field conditions to determine their adaptation to critical environmental factors.

2. Determine mode of reproduction and identify other plant characteristics that might be deterrents to economic production.

3. Determine range of genetic variation and identify superior germ plasm.

Potential Benefits: This preliminary evaluation of new crop plants under a wide range of conditions is a critical process in the development of new crops. Information gained from these studies will help determine which species merit more intensive research effort to develop superior varieties or to improve cultural practices. Some of these plants will become established crops on small acreages, and an occasional one may expand to major importance occupying millions of acres.

Recommended Research Effort: See last paragraph, page 21 and table, page 6.

MECHANIZATION OF PRODUCTION OF MINOR OILSEEDS, MISCELLANEOUS AND NEW CROPS

RPA 308

Situation: The crops being considered are either grown on relatively low acreages or are not being grown commercially at all. Therefore, farm machinery manufacturers are less inclined to give attention to the machine needs for these crops. Yet the success of some of the new crops may depend on how well planting, growing, and harvesting can be mechanized. Machines designed for use with major crops are used effectively for many of these crops but modification of design of specific components would greatly improve efficiency. Engineering research should be conducted in close cooperation with plant genetics and cultural operations in order to provide varieties and the kinds of plants better adapted to machine operations.

Objective: Develop machines and improve machine components to plant cultivate, harvest, and handle specific crops and modify varieties and cultural practices to enable mechanized operations.

Research Approaches:

A. Development of machines and improved machine components to plant, cultivate, harvest, and handle other oilseeds, miscellaneous, and new crops.

B. Modification of varieties and cultural practices so as to provide new crop plants adapted to mechanized operations.

Potential Benefits: Lower unit production costs for existing and developing crops. Mechanization that proves to be a major factor in establishing a new crop can be credited with an entire new industry and a new alternate enterprise for farmers.

Research is recommended but specific SMY allocations would depend upon the stage of development and importance of the crop.

Recommended Research Effort: See footnote 4, page 6.

SYSTEMS ANALYSIS IN PRODUCTION OF MINOR OILSEEDS, MISCELLANEOUS AND NEW CROPS

RPA 309

Situation: For crops with limited markets or demand and new crops, producers need to quantify the advantages or disadvantages of these crops as compared to other field crops which are grown. The availability of high-speed electronic computers and newer analytical methods, has opened the way to more comprehensive analyses of alternatives in crop production. Systems analysis can provide information that will contribute to a more orderly expansion of minor or new crop acreages. Within the older and more fully developed crops, such as some of the oilseed crops, the best alternative among management techniques can be determined.

Objective: To determine the best choice of crops and crop sequences among minor oilseed, miscellaneous, new, and major field crops and the best management alternatives for those crops on which extensive production and research data are available.

Research Approaches:

A. Develop and use mathematical models to determine the best crops and crop sequences under specified alternate sets of conditions involving input costs, relative productivity, production factors, and potential markets.

B. Apply mathematical models for simulating flax and other well established crop production systems. Simulated differences in varieties, nutrients, water, herbicides, and other elements of management practice will be compared to determine most productive and economical combinations of elements.

Potential Benefits: A more orderly increase of new and minor crops as the seed and market demands for them develop. For well established or existing crops lower cost per unit of production can be expected. Experience with systems analysis for these crops is too limited to attempt to quantify benefits. Benefits will be greatest when minor oilseeds, miscellaneous, and new crops are included in more broadly analyses involving major crops and livestock enterprises.

Recommended Research Effort: Research effort on systems analysis need not be allocated specifically to these crops, but these crops should be included in comprehensive studies that deal with field crops generally. Research is recommended but specific SMY allocations would depend upon the stage of development and importance of the crop. See footnote 5, page 6.

CONSUMER ACCEPTABILITY

RPA 405A

Development of improved production practices to achieve optimum contents of desired components

Situation: Quality traits, such as fiber strength and oil content, are known from studies on many crops to vary with changes in environment. Environmental factors identified as having major effects upon quality are soil moisture and air temperature during critical stages of plant development, soil fertility (especially nitrogen), and infestation by disease, insects, or weeds.

Information is lacking on the optimum environmental conditions that are necessary to achieve the best quality of most crops under discussion. If the general acceptance (new crop) or potential for expansion of a crop is dependent upon the quality of a component, information will be needed on the possibilities of enhancing quality through modification of environmental factors.

Objective:

A. Gain information on response of crops, particularly promising new and developing crops, to changes in environments as reflected in quality traits.

Research Approaches:

A. Supplement, with quality measurements those studies designed to evaluate genotypic and environmental effects upon yield.

B. Conduct critically controlled environmental studies on response (as reflected by quality of desired component) of crop species to controllable environmental factors (e.g., soil moisture, daylength, soil fertility).

Potential Benefits: Improved quality through modification or improvement of quality of principle component may cause the crop (new) to have a market and thereby acceptable for commercial production. Improvement of quality resulting from near-optimum growing conditions, will likely enhance the value of the crop thereby encouraging expanded acreages and higher market values.

Recommended Research Effort: See table, page 6.

CONSUMER ACCEPTABILITY

RPA 405B

Determination of genetic bases for chemical properties and composition

Situation: Quality attributes are particularly important to the acceptance or expansion of production of the crops discussed in this report. Information is lacking on the inheritance and range of variability of quality characteristics of the new and developing crops. Some genetic information is available on the established crops.

There are evidences that quality traits can be changed substantially by breeding through use of efficient laboratory analysis techniques applied to carefully planned breeding populations. The oil content of sunflowers was raised from 30 to 40% by mass selection in Russia. The erucic acid component of rape oil was lowered from 40% to 0% by Canadian rape breeders. Oil content of flax in Imperial Valley, California, was increased from 38 to 44% by variety improvement. Studies on safflower at University of California have shown that linoleic acid in safflower oil can be varied from 15 to 78% by variety selection.

Objective:

A. Survey the available germ plasm of promising crop species for range in quality attributes such as amount and quality of fiber, oil, or other component.

B. Gain genetic information in order to devise efficient breeding procedures for quality improvement.

C. Develop, where needed, satisfactory techniques for measuring quality characters.

Research Approaches:

A. Conduct laboratory analyses of plants representing available germ plasm grown under uniform environment (particularly for new and developing crops).

B. Based on above analyses, select appropriate stocks for use in genetic and breeding studies that are designed to improve quality traits. Information gained from genetic studies of quality traits of other crops will greatly facilitate planning of experiments.

C. Develop or modify apparatus and procedures for the efficient analysis of large numbers of small samples for such traits as fiber strength, composition of oil, or percentage of some important chemical component.

Potential Benefits: Improving or modifying a quality trait through breeding will cause the commodity to become more acceptable to consumers, make the commodity more competitive, and may stimulate new kinds of uses. Such improvement or modification will be achieved without increase in production costs.

Recommended Research Effort: See table, page 6.

C. Product Development and Quality - Goal IV

In the "National Program of Research for Agriculture," under Goal IV, the objective is to expand the demand for farm products by developing new and improved products and processes and enhancing product quality. Within this objective the research effort would be aimed at (1) developing varieties and strains of crops having attributes that meet the preferences and desires of consumers; (2) improvement of production practices, processing methods and marketing procedures so as to preserve or enhance inherent qualities of farm products; (3) development of new and improved products from agricultural commodities by tailoring products to meet customer preferences and by increasing product utility for the consumer per unit of input.

The objective was further broken down into 12 research problem areas of which three will be discussed in this section: RPA 406, New and Improved Food Products From Field Crops; RPA 407, New and Improved Feed, Textile, and Industrial Products From Field Crops; and RPA 408, Quality Maintenance in Marketing Field Crops. RPA 405, pertaining to production for consumer acceptability is discussed in the previous section.

Much of the research in this goal contributes to the success of other goals. The success of U. S. products in foreign markets depends in part upon their quality. This research contributes to consumer health and well-being. Also it provides basic information for the improvement of grades and standards, and, by increasing the shelf life or by reducing the bulk of products, it reduces the cost of marketing. As product development increases demand and market outlets, it contributes to the level of living and the prosperity of rural communities.

Soybeans, safflower, and castor beans are examples of crops that have grown in importance and achieved success in the last 30 years. Utilization research has contributed to the development of such crops by providing an important bridge between the producer, the processor, and the consumer. All gain from a vigorous utilization research effort that helps to develop new crops, new uses, maintain present uses, and to provide superior products and processing methods for farm products. The individual farmer cannot develop basic knowledge of chemical composition and physical properties of farm commodities. Yet such knowledge and its application are needed to develop the product and process technology for maximizing utilization of agricultural commodities. Therefore, the research must be carried out by State and Federal agencies and educational institutions.

Utilization Research proposed is described below under the categories (1) established crops, (2) developing crops, and (3) new crops. Within the broad category of "minor oilseeds, miscellaneous, and new crops" the Task Force had insufficient breakdown or guidelines to allow specific comparisons of recommendations for particular commodities or lines of work. The Task Force has itemized selected needs and opportunities where it visualizes constructive benefits through utilization research, and has recommended SMY assignments that it feels are required to do the job. The multiplicity of crops and potential crops to be considered has necessitated subdivision into a number of subcategories within RPA 407 and 406 so that the situation and problems for each commodity could more accurately be set forth.

1. Established Crops

Situation: Flax, castor, tung, safflower, and sunflower are oilseeds that have a vital place in the cash farm economy of particular regions of the country. In our rapidly changing economy products from those commodities are under continuous pressure from competing materials, which are frequently of nonagricultural origin. Aggressive research to modify the agricultural materials, or their processing, adequately to meet flexible market conditions is essential for retention and expansion of market penetration.

The decision not to write a specific RPA for crops such as sesame, guar, buckwheat, mint, or hops does not necessarily mean that the Task Force feels that no effort will be warranted by 1977. It does reflect a current judgment that utilization research is not limiting for the solution of urgent problems that may exist for those crops. For example, an established market exists for guar gum and two processing plants are operating in this country. However, due to a combination of economic and production factors a major proportion of U. S. guar needs continue to be satisfied by imports. Utilization research on guar may be required to solve problems at a future date.

Sunflower as an oilseed crop might more properly be classified as a developing instead of an established crop in this country. However, because of some similarities in markets and in research approaches required it is considered here along with safflower. A small amount of industry-supported utilization research on hops is conducted by the USDA.

Recommendation: The Task Force recommends utilization research on established crops that are within its assignment as detailed in RPA's 407A, 407B; 407C, 407D, 406A, and 406B.

2. Developing Crops

Situation: As in the case of assigned established crops above the Task Force recognized the potential of additional developing crops not discussed in detail, such as plantago and *Dioscorea* as mucilage and pharmaceutical crops respectively. However, the utilization aspects are not limiting and specific manpower assignments for utilization research are not now suggested on those crops.

Crambe, a new oilseed crop commercialized in 1965, is the first plant included in the utilization program on new crops to achieve this status. In 1968 the first named variety, 'Prophet,' was released. Crambe is but one representative of a group of promising oilseeds, including rapeseed and mustard, that contain high-erucic oils. They have been under-researched. With a "foot-in-the-door" having been established for their commercialization research emphasis to take advantage of the situation seems warranted and desirable.

Recommendation: The Task Force recommendations are encompassed in RPA 407E.

3. New Crops

Situation: To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the US; (2) detailed physical and chemical studies on components of interest to obtain clues to likely end uses; and (3) selection of the most promising species, followed by additional utilization research to explore uses and demonstrate industrial potential, as well as by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one, and the discovery and development of a plant into an economic crop is a difficult undertaking. Yet, whether the future of agriculture involved conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

Utilization Research has the specific function in an interdisciplinary new crops program of developing chemical, biological, and engineering information and evaluations that will provide for selection of candidate plants for crop development, for demonstrating in development studies their conversion into valuable products, and for developing basic chemical and physical data that increase our knowledge of the plant kingdom.

Recommendation: Task Force recommends an aggressive utilization research program on new crops as detailed in RPA's 407F, 407G, 407H, and 406C to continue the impetus given this field since Utilization Research on new crops was initiated in 1957.

IMPROVED FOOD PRODUCTS FROM SAFFLOWER AND SUNFLOWER

RPA 406A

Situation: Safflower and sunflower oils are desirable edible oils because of high content of linoleic acid. Reactivity of safflower oil with oxygen both at high and at low temperatures, limits its use to applications where oxidative stability is not a paramount consideration. Cooking with safflower oil leads to off-odors and flavors and to formation of polymeric products. New varieties of safflower have been developed which have up to 25% greater yields per acre than current commercial varieties, but they have off-odors and dark colors. One other new variety of safflower which can soon become commercial has an oil containing ca. 80% oleic acid. Sunflower oil in quantity is relatively new to the American market but substantial amounts are now available and the crop is expected to increase in importance. Performance characteristics, limitations of the oil, and preferred processing, additives and uses consistent with U.S. practice need to be determined.

Safflower meal has 20-22% of a good quality protein. It can be decorticated to a 42% meal, but this product has ca. 15% crude fiber which makes it unfit for human consumption. In addition safflower meal contains a bitter principle and a laxative principle. Sunflower meal contains pigments which, unless removed, carry into protein isolates.

Objective:

1. To produce maximum yields of light-colored odorless safflower and sunflower oils with high storage stability which is suitable for cooking.

2. To develop palatable nutritious protein isolates and concentrates from safflower and sunflower meals suitable for human consumption.

Research Approaches:

1. Analyze and determine the chemical reactions leading to formation of deleterious odors, flavors and polymeric materials during heating of safflower and sunflower oils. Develop stabilizers, inhibitors, sequestrants or other means of preventing such reactions.

2. Screen safflower and sunflower varieties for natural antioxidants.

3. Study the stability behavior of the new safflower variety having high oleic acid content.

4. Isolate and identify the natural pigment and odor components in safflower and sunflower. Develop ways to remove these.

5. Develop commercially feasible ways to concentrate and isolate protein from safflower andssunflower and make it suitable for human consumption.

6. Identify trace constituents of oil and meal that may affect processing and utilization.

7. Investigate low degrees of selective hydrogenation and presence of trace metals relative to effects on oil stability.

Potential Benefits:

1. Production of stable oils for cooking.

2. Minimize costly hydrogenation and winterization processes for stabilizing vegetable oils.

3. Better nutritional quality for cooking oils.

4. Greater export markets for vegetable oils and oilseeds.

5. New technology applicable to other oilseeds.

6. Production of low cost high-protein food from meals.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
8	11

NEW USES OF CASTOR OIL IN FOOD PRODUCTS

RPA 406B

Situation: Castor is a western oilseed crop which produces a unique oil containing 90% of the hydroxy unsaturated acid, ricinoleic acid. The oil is used industrially in many applications, e.g., coatings, pharmaceuticals, cosmetics, plasticizers, and surfactants. The cathartic effect of castor oil has long been well-known. Consequently castor oil has not been used in applications related to food in this country. One of the unique physical properties of castor oil and hydrogenated castor oil is their ability to thicken and impart thixotropic properties to oil-based formulations such as paints, lubricants, gelled fuels, etc. There are applications in food technology in which the same properties are desirable, e.g., butter substitutes, peanut butter, salad dressings, and the like. Most thickeners now used work best in a water base rather than an oil base.

Objective: To develop the use of noncathartic castor derivatives as food additives.

Research Approaches:

1. Determine the effects of hydroxy fatty acids, particularly hydroxystearic acid in animal and human diets.

2. Determine the mechanisms of metabolic degradation of ingested hydroxy fatty acids.

3. Test the nutritional effects of small amounts of hydroxy fatty acids on oil-based foods.

4. Evaluate the storage stability of temperature effects on and physical properties of foods containing hydrogenated castor oil and other hydroxy fatty acid derivatives.

Potential Benefits:

1. New types of thickeners for oil-based foods.

2. Low cost for a unique food additive conferring special properties.

3. Increased value for castor oil.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
1	2

NEW SEED SOURCES OF PROTEIN OF HIGH NUTRITIONAL QUALITY

RPA 406C

Situation: Large numbers of the world's people suffer from protein malnutrition. Even in the United States which has an abundance of food a significant number of people are undernourished. To improve nutritional levels and to accommodate population increase we should accelerate efforts to find practical new sources rich in high quality protein. The cheapest source of protein is from plants. Seeds contain nutrients in a concentrated form, readily harvested, transported, stored, and processed. Plants offer enormous possibilities as a means to increase both quantity and quality of protein for human food. Selected grains and legumes already form the bulwark of the human food supply. However, present crops might effectively be supplemented by additional ones that have high quality available protein and no persistent antinutritional factors. Opportunity exists for such a new crop if it can meet at least one of the following conditions: (1) the protein is cheaper than that in soybean meal; (2) it occurs as a coproduct with an oil that fills an industrial need for which soybean oil is not suited; (3) the crop produces high protein meal without contributing to a surplus of edible oil; (4) it will grow in areas where soybeans are not adapted; (5) its value in minimizing insect pests and plant diseases through crop rotation combines with the commodity value to justify production; (6) the flavor and texture of foods prepared from it are desired by various people; or (7) the nutritional quality of the food, alone or as a supplement to cereals, is equal or superior to that of soybeans. Preliminary chemical surveys of seed from wild plants show that a substantial percentage have high protein content. Some also have amino acid composition desired for human food, alone or as grain supplements. Further attention to these species and others to be screened and characterized offers possibilities for the development of new protein crops from unexplored plant sources to meet future requirements for dietary proteins.

Research Approaches:

1. Chemical survey of selected high-protein seeds to find desirable amino acid composition.

2. Test samples of desirable amino acid composition and promising agronomic potential for nutritional quality by animal feeding tests. Investigate any that contain deleterious factors to identify the factors and devise practical means of neutralizing or eliminating them.

3. Study solubility characteristics of seed proteins as they relate to the isolation of protein concentrate as a food source.

4. Follow protein quality in the course of needed plant breeding work to assure that quality is maintained in developing suitable agronomic strains.

Potential Benefits: New high quality food protein at minimum cost. New foods for export. New functional properties in high protein concentrates for mixes and convenience foods. New crops for diversification to benefit farm economy.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
3	4

NEW AND IMPROVED INDUSTRIAL PRODUCTS FROM LINSEED OIL

RPA 407A

Situation: Use of linseed oil in traditional outlets such as printing inks and outside paints, has declined from 500 million in 1956 to about 300 million in 1966. Additional decline is predicted through 1976. This crop fills a vital place in the cash economy of the major growing area of North and South Dakota and Minnesota. It can be planted later than other cash crops and the farmer still realizes a profit on his operation. Improvements in linseed oil emulsion paints and research on the protection of concrete from salt and freeze-thaw cycles by application of linseed oil antispalling compound to the various surfaces have helped to slow the decline in markets. Additional opportunities exist for the use of linseed oil in improved vehicles for exterior paints, in linseed oil-coated pigments for emulsion paints, in branched, cyclic and new straight chain derivatives for chemical intermediates, and in new or superior methods of using linseed oil for curing and/or protection of surfaces such as concrete.

Objective: To increase nonfood uses of linseed oil by studies on methods of using linseed oil in emulsion paints, by studies on the application of the oil or its derivatives to preserve structural materials such as concrete, and by chemical modification to give new derivatives for the chemical industry.

Research Approaches:

1. Develop and test new linseed oil emulsion paints and other linseed oil compositions for the protection of wood, steel and concrete.

2. Prepare and develop new chemical intermediates from linseed oil.

3. Evaluate new products and processes for specific uses.

4. Adapt procedures for chemical modification of promising products to continuous low-cost processing.

Potential Benefits: New or expanded outlets for linseed oil in nonfood uses should materially aid farmers particularly in the North Central States of North and South Dakota and Minnesota. Such outlets would help stabilize prices by diversification of markets. Outlets for protective coatings, industrial and agricultural chemicals and related industries totaled more than 12 billion pounds in 1964. Previous success with dimer acids, polyamide resins and epoxy oils with other oils and more recent work on the use of linseed oil on concrete show that linseed and other oils can share in these increasing outlets.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
20	22

NEW INDUSTRIAL AND NONFOOD USES OF CASTOR

RPA 407B

Situation: Castor produces a unique oil, containing ca. 90% of the hydroxy-unsaturated fatty acid, ricinoleic acid. The oil is used industrially in many applications, e.g., coatings, pharmaceuticals, cosmetics, plasticizers, and surfacants. Castor oil is finding increasing use in urethane polymers. Recently 80-90% of the U.S. needs for castor oil have been met by imports. In 1967, crop failure in Brazil caused the price of castor to rise from 15 cents to 25 cents per pound. Aggressive action by farmers has increased U.S. castor acreage three-fold in 1968.

Although castor pomace has a protein content of ca.35%, it contains a toxic protein and several potent allergens. These materials can be deactivated by further processing. Castor meal has been used largely for fertilizer but the increased supply now requires development of animal feed uses.

Objective:

1. To develop foams, elastomers, adhesives, coatings, plasticizers, slip agents, anti-block agents and other chemicals useful in the plastics industry, from castor oil at prices lower than those of products from non-agricultural sources.

2. To develop and achieve commercial adoption of processes to detoxify and deallergenize castor pomace.

3. To determine the nutritive qualities of processed castor meal of different fiber content for use in least cost linear program feed calculations.

Research Approaches:

1. Develop new castor-based urethane foams, especially fire-retardant foams, and ways to apply these foams.

2. Develop and test elastomeric products derived from castor oil.

3. Prepare vinyl monomers, amine derivatives, oxidized and isomerized derivatives from castor acids.

4. Develop commercially feasible means of detoxification and deallergenization of castor pomace by steam, lime, or ammonia treatments.

5. Evaluate deallergenization procedures by *in vitro* and *in vivo* tests.

6. Establish nutritional qualities of treated castor meals through feeding tests.

Potential Benefits:

1. Urethane foams and elastomers with superior properties at lower cost than nonagricultural products.

2. New improved monomers, plasticizers, and other chemicals from castor oil fatty acids.

3. Greater utilization of a domestic replacement crop, thus decreasing subsidy payments.

4. Elimination of hazardous agricultural residues.

5. Increased value of castor pomace.

6. Provision of a cash crop for rotation programs and for acreage diverted from surplus crops.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
12	12

NEW AND IMPROVED USES FOR SAFFLOWER AND SUNFLOWER IN INDUSTRIAL PRODUCTS AND ANIMAL FEEDS

RPA 407C

Situation: Safflower has been a rapidly growing western oilseed and sunflower is a developing domestic oilseed crop which are attractive because of high linoleic acid content. Safflower is a good drying oil, producing non-yellowing surface coatings. Partial conjugation of the acids in the oil by chemical isomerization gives an oil with even better drying properties. While food use of safflower oil has grown rapidly, industrial use has increased more slowly. Sunflower oil is sufficiently new, in size quantity, on the domestic market that fuller appraisal of its high potential is required. Safflower meal contains 20-22% protein. It can be partially decorticated to 42% protein meal, but this meal still contains ca. 15% crude fiber. Such meal is satisfactory for ruminants but the high fiber content as well as presence of a bitter principle and laxative principle may limit its use in non-ruminant feeds. The separated hulls are used only for roughage because of their high lignin content. Sunflower hulls comprise a fourth or more of the achene as harvested. Upgrading to develop preferred uses will improve economics of sunflower utilization.

Objectives:

1. To develop new coatings, plasticizers, monomers, and industrial raw materials from safflower and sunflower oils.

2. To achieve inexpensive methods of processing meals to produce palatable high protein, low fiber products for feeding poultry and swine.

3. To develop methods to increase the biological availability of carbohydrate and protein in highly lignified safflower hulls, and to upgrade sunflower hulls for feeds or other uses.

Research Approaches:

1. Prepare useful derivatives from safflower and sunflower oils and their fatty acids, by isomerization, oxidation, ozonolysis, free radical addition, and other processes.

2. Prepare palatable, nutritious low-fiber meals by commercially feasible processes, and evaluate as feed for non-ruminant animals.

3. Develop commercial processes to increase digestible carbohydrate and protein in highly lignified hulls and meal by chemical, physical, and biological treatments.

4. Develop non-feed industrial uses for hulls by making optimum use of their physical and chemical composition.

Potential Benefits:

1. Lower cost chemical products from agricultural raw materials.

2. Lower production and consumer costs for meat and dairy products.

3. Beneficial utilization of fibrous material now used only for roughage.

4. Better nutritional quality of safflower and sunflower meals, giving increased income to producers.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
8	12

NEW AND IMPROVED PRODUCTS FROM TUNG OIL AND MEAL

RPA 407D

Situation: Tung production was introduced into parts of the Gulf Coast area because it offered the best opportunity for a cash crop under the limiting agronomic conditions existing in those regions. Production of tung fruit and oil fluctuates widely because of frequent frost damage. Maximum production of tung fruit (132,000 tons), valued at 10.5 million dollars, was in 1952. Average production during the past five years was 49,000 tons valued at $4.4 million at the farm level. Average production of tung oil was 21 million pounds and domestic consumption during this period averaged 32 million pounds. Imports averaged 25 million pounds, resulting in a large increase in stocks and decrease in price to record low levels. The entire domestic consumption of tung oil goes into non-food uses, chiefly in drying oils for surface coatings. Post WW II consumption reached a maximum of 130 million pounds in 1948, but has declined gradually since then. Opportunity exists for regaining markets largely lost to synthetics as tung oil is exceptionally well adapted for use in surface coatings and production of numerous chemicals of potential industrial utility at stable prices. Tung meal is currently used exclusively as a fertilizer, but if detoxified could be a source of protein for animal feeds thereby contributing added value to the products from tung.

Objective: To increase industrial utilization of tung oil by development of new and improved surface coatings and by chemical modification to produce plastics, adhesives, chemical derivatives, etc.; to develop detoxified tung meals to provide protein constituents for animal feeds.

Research Approaches:

1. Develop new tung oil based surface coatings, plastics, and resins for industrial use.

2. Evaluate tung oil products and processes for specific uses.

3. Develop improved procedures for detoxification of tung meal, including analytical methods for assuring freedom from toxicity.

Potential Benefits: Increased utilization of tung oil and meal should increase total farm income, stabilize prices, and diversify markets. Tung is the best cash crop in areas of current production. These areas could be expanded with increased demand. Increased utilization would also tend to prevent migration of rural population to urban areas. Outlets for industrial organic chemicals in plastics, agricultural chemicals, and related industries total more than 10 billion pounds annually. Penetration of these markets could further increase utilization of tung oil significantly. In addition, tung oil offers the potential for the development of products with properties not presently obtainable. For example, durable tung oil coatings could protect electrical equipment undergound for up to 50 years. Such a development would contribute significant economies to electrical distribution systems which, if relocated underground would preserve the natural beauty of America.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
6	10

NEW AND IMPROVED INDUSTRIAL AND FEED USES FOR HIGH-ERUCIC OILSEEDS SUCH AS CRAMBE, RAPESEED, AND MUSTARD

RPA 407E

Situation: Until recently there was no domestic production of high erucic oilseeds nor was there research before the last five years or so on their utilization. The potential importance of these oilseeds as a U.S. crop is disproportionate to the attention they've received. Rapeseed ranks fifth among the major oilseeds of the world, annual production being over five million tons. Exemplifying the potential, Canadian rapeseed production more than tripled between 1962-63 and 1966-67. Rapeseed is now grown there on about 1 1/2 million acres, replacing wheat which was produced in excess of needs, with concomitant benefit to Canadian farmers. There are species and varieties of high-erucic oilseeds that grow well in the United States. One of these, crambe, has entered limited commercial production as a new U.S. oilseed crop as a result of USDA and SAES research. Present production of crambe oil is used as a mold lubricant in continuous casting of steel and the coproduct meal is blended with other ingredients for use in ruminant feeds. Market demand is strong for crambe oil at the present time.

High erucic oils offer minimum competition to other domestic vegetable oils. This is because the erucic acid which does not occur in soybean, linseed, cottonseed, or peanut oils has a long carbon chain length in its molecule that confers unique properties. The threefold area of utility of high-erucic oils includes usage of the oil itself, of erucic acid derivatives from it, and of a new chemical, brassylic acid, derived from erucic acid. A potential market for some 200 million pounds of high erucic oil can be envisioned provided research is successful in developing suitable products and economic processes. For example, a new nylon just prepared in the laboratory from erucic acid has excellent properties and samples are under evaluation by industry. Full exploitation of the potential of high erucic oilseeds requires research both on new chemical products from the oil and on improvement of the coproduct feed meal to render it usable without restriction by nonruminants as well as ruminants.

Objective: To develop new products and processes to expand markets for high erucic seed oils by exploiting their unique properties and to upgrade meals from high erucic oilseeds for feed use so that the oil may be most favorably priced.

Research Approaches:

1. Chemically modify high erucic oils and derived products to prepare lubricants, greases, rubber compounding agents, fibers, plastics, waxes, surface active agents, plasticizers, water repellent agents, and chemical intermediates.

2. Develop biochemical and processing information on high erucic oilseeds that will lead to improved extraction procedures and meals of enhanced feeding and nutritional quality.

Potential Benefits: Provide farmer with more options in land use, particularly during recurrent periods of excess acreage of grains; new versatile raw materials for the chemical industry; superior consumer products; generation of medium-sized business opportunities in rural communities.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
12	12

PAPERMAKING PULPS FROM ANNUAL FIBER CROPS

RPA 407F

Situation: It is estimated that demand for paper and board will double by 1985--supported largely by increased home construction and the ever-increasing needs for packaging. In 1968 housing starts in the U.S. of 1.6 million were slightly under the level attained in 1963 but about 20% over 1967. As we look ahead it is expected that normal housing needs from population growth and replacement will be augmented by anticipated programs of upgrading run-down houses and slum area renewals. Latest plans call for substantial acceleration in construction of new and improvement of existing houses during the next 10 years. The use of fibrous material in packages has increased tremendously in recent years and no letup is in sight. The use of package material for individual portions and units has increased considerably together with the use of cardboard boxes for wholesale and large quantity movement of these small packaged items. Not only are small items packaged but household goods such as refrigerators, stoves, and mattresses are packaged in cartons made of fibrous material.

Projections by the U. S. Forest Service and others indicate that by 1980 new growth will not meet demand at present level of timber management. Some factors which bear on the future supply of pulpwood are: diversion of forest lands to recreational and watershed uses; increasing costs of harvesting and transportation; low returns per acre from timber; and small owners who hold a high proportion of the South's commercial forest acreage, and who have little interest in improvements in forest management practices.

Demand for pulpwood in Southern areas of the U. S. has grown rapidly in recent years. This increase has brought a rapid decrease in supply of hardwoods used in combination with softwoods for many grades of pulp. Kenaf is an annual species with fiber qualities suited to supplement hardwood fiber supplies in pulp and papermaking. A feasibility study by the Economic Research Service, USDA, placed kenaf's potential as an economic crop between corn or soybeans and cotton. Because of these favorable economic conditions as a new crop and its utilization development potential, kenaf research and development programs should be intensified.

Optimum methods for producing and harvesting kenaf as a pulp crop have not been fully established, and cost data based on actual experience with kenaf are not yet available. Also, a preferred system for storing and handling kenaf after harvest to maintain raw material quality remains to be developed. Because kenaf is produced seasonally and is bulky, storage and handling costs may be somewhat higher for kenaf than for pulpwood. On the other hand, cost of processing kenaf may be somewhat lower than for pulpwood, especially in a mill designed especially for kenaf pulping.

In switching from a raw material such as wood to a new type of crop, a large-volume installation such as a pulp mill must resolve handling and processing procedures incident to the change. The types of pulps and paper products for which kenaf and related materials are best adapted remain to be determined, as does the development of optimum properties and preferred pulping, bleaching, and converting methods.

Objective: To ascertain and delineate how desired market grades of paper products can be most easily and most cheaply derived from kenaf or kenaf-wood pulp blends.

Research Approaches:

1. Determine optimal processing conditions for preparation of bleached and unbleached chemical, semichemical and chemi-mechanical type pulps from kenaf after selected handling and storage treatments of the green and field-dried crop, and evaluation of resulting pulps and the papers derived therefrom.

2. Determine the nature of the principal physical and chemical constituents of kenaf and the effect of their presence or absence upon the quality of pulp prepared therefrom.

3. Utilize the Forest Products Laboratory in evaluating pulping and papermaking characteristics of annual fiber crops in comparison with those of common wood fibers.

Potential Benefits:

1. Production of kenaf in the South would more fully utilize the agricultural resources of the area by growing an annual crop that has a potential of returning more income per acre than timber.

2. It would provide a stable dependable raw material supply for pulp mills.

3. It should help keep the prices of paper and board at reasonable levels.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
6	6

UTILIZATION RESEARCH TO DISCOVER AND DEVELOP NEW CROPS SUCH AS OILSEEDS, AND PLANT SOURCES OF GUMS, SPECIALTY STARCHES AND PEST CONTROL AGENTS

RPA 407G

Situation: Agriculture in the United States faces the paradox of withdrawing acres from crop production and serving as the world's largest exporter of food fats and oils while at the same time importing not only huge quantities of vegetable oils but also the water-soluble gums for industry, rotenone-bearing roots as insecticides, and other plant materials. The imports are specifically needed because of chemical composition required by American industry and not adequately provided by domestically produced crops. This situation in itself argues for development of new domestic crops to benefit the general economy. Research already completed demonstrates that plants not now in cultivation are sources of attractive new chemical raw materials. Though less than two percent of the known quarter million species of higher plants have been chemically surveyed, over 40 new substances have been discovered and found to have characteristics that suggest commercial application; new sources of presently used materials have also been found. Examples are: Lesquerella, new oilseed with 20-carbon hydroxy acid for foamed plastics and special lubricants; Indian ironweed, epoxy oil for plasticizers, stabilizers for plastics, chemical intermediates; petroselinic acid oils (parsley family), for nylon type polymers and surface active agents; Briza (a grass) as a source of bread additive to increase loaf volume; Limnanthes (meadow foam) seed oil for liquid waxes, plasticizers, printing ink additives; Cassia and related legumes for water-soluble gum for paper production; Tephrosia, a legume with insecticidal action in vegetative part of plant; mustard plant family for high-erucic acid oils for new nylons, lubricants, plastics, plasticizers; Cuphea, an annual plant with a coconut-like seed oil for detergents and edible uses. The list of new useful chemicals from plants could be extended greatly. The rate of further discovery will continue for a long time yet to be proportionate to research effort expended. Following chemical discoveries, intensive interdisciplinary efforts are devoted toward crop establishment of most promising species. The oilseed crambe has received major emphasis and has attained limited commercial production. Markets for crambe oil are increasing. The insecticidal plant Tephrosia is also in developmental stages. Expanded research to expedite crop establishment of additional promising species should be rewarding in benefits to agriculture and industry.

Objective: To discover and develop through chemical and processing research new industrial crops for the United States, by demonstrating useful composition in uncultivated plants and, with the cooperation of plant scientists, the feasibility of making that composition available to industry for needed end products.

Research Approaches:

1. Expand chemical investigation of plant kingdom for amount and type of useful constituents such as seed oils, proteins, polysaccharides, and insecticides.

2. Chemical modification, evaluation, and processing research to develop technology needed for commercial adoption of new crops.

3. Research on uses for coproducts of processing to permit most favorable economic opportunity for primary products.

4. Cooperation at every stage of development with agronomists, botanists, and other plant scientists for a rounded interdisciplinary effort to insure success.

Potential Benefits: Provide farmers more efficient land use through diversification and greater selection of crops when some are produced in excess of needs and depressed in price; reduce dependency on imports and improve balance of payments while providing more stable supply of uniform quality; provide industry needed raw materials; furnish improved consumer products; full practical exploitation and application of accumulated knowledge of plant chemistry; new knowledge for the scientific community on plant chemistry and biochemistry. The application of anticipated new knowledge could bring about substantial increases in national income through such developments as: Domestic vegetable oils at a price 30 percent above that of soybean oil and having properties equivalent to coconut and castor oils; Commercialization of domestically grown *Tephrosia* as an insecticide; and, New seed gum from domestic crop to replace imports.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
20	26

TUMOR-INHIBITING AGENTS AND OTHER BIOLOGICALLY ACTIVE SUBSTANCES FROM PLANTS

RPA 407H

Situation: Plants contain many biologically active substances that are involved in their own normal development or in their protection against diseases and insects. They also have numerous constituents that cause a variety of physiological responses in humans and animals. More of these biologically active substances should be found, identified, and put into service for man since their range of biological activities often include ones needed to contribute to human health and comfort. For example, survey of plants for anti-tumor agents has led to a substantial number of confirmed active materials in experimental tumors. One plant substance found as a result of the program, named camptothecin, successfully passed pre-clinical pharmacological evaluation and has been cleared for clinical trial in human patients. Others are at advanced stages of testing and probability seems high for achieving useful medicinal agents with adequate research input. For extending utilization research to find anti-tumor agents, thousands of samples of plant seeds representing an unusually diverse botanical spectrum are available at the Northern Division. These seeds are required for a chemical screening program directed towards new industrial crops, but can readily be investigated for presence of tumor-inhibitors and other biologically active substances in order to speed the discovery of new effective agents.

Objective: To discover plant materials that contain previously unrecognized biologically active principles, and to isolate and characterize individual compounds in which such activity resides.

Research Approaches:

1. Required plant materials beyond those already available will be supplied by USDA botanists, by workers on Public Law 480 projects, or obtained by purchase, exchange, or gift.

2. Plant extracts will be submitted for biological assay.

3. Extracts will be fractionated systematically, and active fractions will be suitably assayed by contractors or other interested laboratories or clinicians.

4. Individual compounds considered to be of potential practical utility will be isolated and their structures determined chemically to serve for obtaining leads for research to find or synthesize more potent and/or less toxic agents.

<u>Potential Benefits</u>: Improvement in public health and longevity by making available effective agents for human diseases or for pest control, e.g., cancer chemotherapeutic agents, anti-malarial agents, and chemisterilants. Fifty million persons now living in the USA will eventually contract cancer, and a high proportion of these will die of it unless greatly improved methods of treatment become available. Discovery of effective anti-tumor chemotherapeutic agents in plants is one approach that should be thoroughly exhausted in the multi-pronged research fight against cancer.

<u>Recommended Research Effort</u>: (SMY's)

TF Recommendation	
1972	1977
3	3

MARKET QUALITY

RPA 408

Situation: Quality preservation of crops is a continuing struggle at all stages from harvest to final consumption. Any new crop will unquestionably face similar problems and require study of factors involved in avoiding deterioration and in steps required for quality protection. Mold growth and insect infestation may occur. Mycotoxin production may accompany mold growth. Some control treatments may affect the commodity adversely. More subtle enzymatic or oxidative biochemical transformations may also take place. Detection and understanding of the changes should be improved for crops currently produced, and should be developed for new crops. Examples of biochemical changes which may downgrade products are thioglucoside modification in crambe, rapeseed, or mustard prior to processing; development of oxidized products in some sunflower seeds upon long storage; and appearance of hydroxy acids in deteriorated ironweed seeds.

Research Approaches:

1. Study conditions of moisture content and temperature to establish practical conditions to minimize deterioration in storage.

2. Develop or adapt methods for detecting, measuring and controlling changes in storage, transportation, and distribution.

3. Investigate the nature of biochemical changes related to mold growth, insect infestation, fumigation, oxidation, and enzyme reactions in stored products.

4. Develop methods for quantitative determination of insecticide residues.

Potential Benefits: Better control of grade standards. Lower losses and improved product quality. Freedom from mycotoxins. Less expense in quality maintenance.

Research Effort: SMY's	Inventory: 1966	Task Force Recommendation: 1972	1977
SAES	0	1	2
USDA	1	2	2
TOTAL	1	3	4

D. <u>Efficiency in the Marketing System - Goal V</u>

In the "National Program of Research for Agriculture," the part pertaining to marketing is contained in Goal V, "Efficiency in the Marketing System." Under this broad goal for all of agriculture are the following objectives: (1) to provide farmers with better market guides for making production and marketing decisions; (2) improved quality and availability of production items and services; (3) facilitate distribution of products; (4) improve the quality and availability of products to the consuming public; and (5) reduce the resources required in the transfer of products from farm to consumer.

These objectives were broken down further into ten research problem areas of which two were assigned to this task force. They are RPA 501, Improvement of Grades and Standards; and RPA 504, Physical and Economic Efficiency in Marketing Field Crops. The other RPA's, pertain to supply, demand, and price analysis (506); competition (507); domestic market development (508); marketing firm and system efficiency (509); and farmer bargaining power (510). These problem areas pertain to the entire agriculture marketing system of which marketing new crops, miscellaneous crops, and minor oilseeds are a part. In using the commodity approach for this report these factors will be dealt with in RPA 504.

The task force in evaluating the situation in marketing research for minor oilseeds, miscellaneous, and new crops recognized that until there are either expansions in the established crops or greater economic demands for the developing and new crops, a modest number of SMY's is required. The research that is required lies in economic estimates of agricultural potentials and background surveys on which we can base our establishment of priorities for production and utilization research. Unless there is a sound economic future for a new crop, farm and utilization research are purely academic.

GRADES AND STANDARDS

RPA 501

Situation: Grades and standards in the marketing system should reflect an accurate appraisal of the quality of a commodity in relation to its price. Objective, quick, and reliable measures for quality attributes of economic significance are needed along with increasing automation in the use of this information. Flaxseed is the only crop in this group for which official U.S. grades and standards have been established. Most relatively new crops (such as castorbeans, safflower, sesame, guar, etc.) are grown under contract with processors who specify commodity quality factors. As the production of these crops increases, grades and standards will be an aid in establishing central markets. They will help expedite buying and selling transactions based on economic differentials for commodities of varying quality levels.

Objective: To provide grades and standards that will effectively communicate value differences for varying gradations of quality.

Research Approaches:

1. Improvement of grades and standards for flaxseed. The U.S. official grain standards specify that flaxseed shall be graded according to requirements of numerical grades (Nos. 1 and 2) and sample grade. Factors used in grade determinations are test weight per bushel, moisture, damage, and "fire damage" after removal of dockage. Research should evaluate the effectiveness of existing grade standards in serving the needs of sellers and buyers and for reflecting different gradations of quality which affect value and use.

2. Development of grades and standards for other oilseeds and food crops. The need should be determined for grade standards for established crops and those to be developed in the future for which grade standards do not exist. Quality characteristics desired by buyers and sellers should be determined with appropriate economic differentials based on varying levels of quality. Once grades and standards are developed, they change little over time and often can serve as a model for future new crops.

3. Determination of product attributes affecting grades and standards for developing crops. Develop descriptive terminology for grade standards which will characterize the different attributes of new crops so as to facilitate communication between buyer and seller.

4. Isolation of product characteristics leading to development of grades and standards for new crops. This requires the development of a uniform system of grades recognizing those characteristics which reflect value and affect use.

Potential Benefits: Development of grades and standards are necessary for buyers to obtain product characteristics desired and for producers to obtain a fair price for what they market. Most of the relatively new crops do not have ready markets, so the development of grades and standards will aid in the establishment of wider marketing outlets. Accurate description of products should provide more reliable market information to sellers and buyers. Prices should more accurately reflect value differences for varying gradations of quality. Effective grades and standards can reduce marketing costs insofar as individual lots do not have to be personally inspected.

Recommended Research Effort: (SMY's)

TF Recommendation	
1972	1977
7	7

(No SMY allocations in Inventory of Agricultural Research)

MARKET EFFICIENCY

RPA 504

Situation: As individual agricultural commodities become established in channels of commercial trade, each tends to develop its own pattern of marketing. Small volume crops, those with specialized outlets, and new crops on the horizon face unique marketing situations in which inefficiencies can seriously impede their development and growth. Moreover, change often occurs rapidly in production practices, production locations, product utilization, and marketing procedures for such commodities. Inefficiencies may appear in physical handling, such as transportation, storage, and processing, in organization and institutional arrangements for marketing, or in evaluating economic potentials in domestic and foreign markets. Prompt changes in marketing institutions and practices may be essential to enable these commodities to compete effectively for markets. Marketing research on a continuing basis is required to identify impediments and inefficiencies and to develop alternatives for improvement.

Objective: To analyze marketing functions, marketing systems, and potential marketing outlets in order to obtain information which would increase efficiency and enhance competitive market positions of minor oilseeds, miscellaneous, and new crops.

Research Approaches:

1. To determine efficiency in performing physical functions, such as transportation, storage, handling, and processing, and to set forth opportunities for improvement. For established crops, this would involve possible changes in functions currently being performed. For developing and new crops, it would be necessary to take into account product attributes, perishability and the like, which would affect the development of facilities, equipment, and channels of trade.

2. Evaluate the organization and operation of marketing institutions and practices in relation to efficiency of the system. Emphasis would be given to buying and selling arrangements, various types of vertical and horizontal coordination, marketing costs and margins, market imperfections, and implementation of new technology. For established crops, procedures in existence would be examined in relation to alternatives. For developing and new crops, guides for effective marketing systems and procedures would be developed, taking into account industry and market characteristics, requirements, and product attributes.

3. Project economic potentials in domestic and foreign markets. This area of research is especially important for developing and new crops. For many established crops it can also be helpful to producers and handlers in planning future operations. Since several minor and developing crops appear to have major potentials in industrial and other nonfood uses, questions of dependable supplies, uniform quality, and stable prices are of considerable importance. Important aspects of market potentials research would include estimation of demand and substitute relationships, identification of possible trade restraints or barriers, determination of market requirements in selected end uses, technical and consumer acceptance of products in different uses and regulatory considerations.

Potential Benefits: Reduction of marketing costs for minor oilseeds, miscellaneous and new crops and expansion of markets for these crops could improve incomes of producer and industry segments and increase benefits to society through lower costs and availability of new and improved products. Inasmuch as several commodities are covered in this report, the probability of significant success from marketing research efforts involving at least some of these crops would seem to be enhanced considerably. Benefits could come not only from lower costs but also from improvements in many other aspects of the economic and social well-being of society. By their nature, potential benefits from physical and economic efficiency for developing and new crops are uncertain. In some cases, effective marketing may make the difference between success or failure of a crop.

Research Effort:	Inventory:	Task Force Recommendation:	
SMY's	1966	1972	1977
SAES	2	4	4
USDA		4	4
TOTAL	2	8	8

APPENDIX I

Economic Potentials of Tephrosia for Rotenone

A. Annual cube root imports - 10 million pounds = 1,125,000 pounds rotenoid resins

(represents highest post-war imports)

B. Estimated value of imports - 10^1 X 10^6 X 15¢ pound = $1,500,000

C. Estimated domestic yield of *Tephrosia* - 2000 pounds of leaves/acre X 5% rotenoids = 100 pounds/acre

D. 10,000 acres produces 1,000,000 pounds *Tephrosia* resins

Cost per acre estimate $100.

Equivalent import value $1,000,000.

E. Present research input on *Tephrosia* in utilization and farm research 4.0 SMY

III SPECIAL REPORT ON MUSHROOMS

III SPECIAL REPORT - MUSHROOMS

Acknowledgement

As a member of the Task Force on New Crops and Minor Oilseeds, R. J. Snetsinger, Associate Professor, Mushroom and Ornamental Insects, Pennsylvania State University, provided leadership for this section on mushrooms. He was assisted by the following persons who served as advisors:

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I INTRODUCTION

Within the general framework of the Long-Range Study, the Task Force undertook to study the means by which the Mushroom research could best be carried out and how it might best be put to practical use. Suggestions have been incorporated which will be useful in organizing extension programs for the mushroom industry. Also, suggestions are included for locating additional mushroom research and extension program centers on a regional basis rather than at a state level.

The Task Force recognizes that mushroom culture represents a unique type of agriculture with aspects of both an established crop and a new crop. In order for mushroom science to prosper, there must be close cooperation and exchange of information between USDA and SAES research and extension workers. Increased travel funds must be available so that regional programs can be successful. At present, only one institution has facilities and staff to provide specific training in various aspects of mushroom science and considerable attention must be given to the training of future research workers in this field. Also, some thought should be given to establishing a technical training program for mushroom growers or to those who wish to enter the mushroom industry. This is because the mushroom industry is likely to undergo a technical revolution within the next few years that will require highly trained technical workers rather than unskilled workers.

Because crop reporting is in its infancy when it comes to mushrooms and because a considerable portion of the mushroom crop is not marketed directly as mushrooms, the U. S. Department of Agriculture mushroom production estimates have not been used. Rather, estimates have been used that in the judgment of the consultants on this report are closer to the actual case. A conservative value of $.30 per pound has been assigned as a market price; however, in areas outside of Pennsylvania prices are often much higher. The yields are reported on the basis of a square foot of bed rather than on dry weight of compost, because while the square basis is less precise, it is more readily envisioned by many people.

Situation: In southeastern Pennsylvania there is the largest concentration of mushroom growers and allied agricultural industries in the world. Additional mushroom farms are also located near the city of Reading and in southwestern Pennsylvania. There are approximately 625 mushroom growers in Pennsylvania who produce 100 million pounds of mushrooms annually. About 5,000 workers are employed in growing these mushrooms and several thousand more are employed in composting, spawn making, processing, marketing, and other aspects of mushroom production. The yearly "on the farm" value of mushrooms in Pennsylvania is about 30 million dollars and the total estimated value to the Commonwealth is about 50 million dollars. About 200 additional growers are scattered throughout the rest of the United States. They produce

an additional 100 million pounds of mushrooms. These 200 growers have farms located near large cities, notably in the states of New York, Delaware, Maryland, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Washington, Oregon, and California. The size of mushroom farms varies from one man or one family operations to those that produce 20 or more tons of mushrooms per day. In general, Pennsylvania has a high percentage of smaller farms; in addition, it has some of the larger farms and many of the allied industries, spawn makers, custom composters, etc. Commercial mushroom production got started in Chester County, Pennsylvania, in 1885 and has largely centered in this state because growing practices were learned from actually growing mushrooms and from other members of the family.

Only one type of mushroom is cultivated in the United States, i.e. Agaricus bisporus - the so-called "commercial mushroom". The mushroom farmer divides mushroom production in the following phases:

A. Composting - Phase I (outside)

Manure, hay, corncobs, and other ingredients are mixed and placed in piles, watered, turned, etc. and allowed to undergo fermentation for 7 or more days.

B. Composting - Phase II (inside)

The compost is moved into a special room or mushroom house for 3-10 days for pasteurization and additional fermentation.

C. Mushroom spawn

Prepared specially in laboratories by professional spawnmakers, is planted on the beds and is allowed to grow for 2 to 3 weeks on the composts in special dark growing rooms at about 75°F and 90% relative humidity.

D. After the mycelium has grown through the composts, an inch of soil is applied.

E. About 14 days after this casing soil is applied, mushrooms appear in flushes or breaks. There are periods of 3 to 5 days of heavy yields followed by 5 to 10 day periods of low yield, before another "break". Mushrooms are harvested for one crop or "a fill" during a period of 40 to 120 days. The average mushroom grower harvests about two pounds per square foot per crop. With air cooling systems, a number of growers operate throughout the year and may produce 4 to 5 crops, other growers without air cooling produce only two crops per year from September to May. The temperature in the growing rooms is held at 55 to 65°F during harvest.

F. The clean-up period follows harvest and plays an important role in control of pests and disease problems in following crops.

At present, almost all of the research and extension work on commercial mushrooms is conducted by the College of Agriculture, The Pennsylvania State University and the Vegetable and Ornamentals Research Branch, Crops Research Division, of the United States Department of Agriculture. Researchers from these two institutions aid in extension type programs. All told, six man years are devoted to research and two man years are devoted to mushroom extension programs. With this arrangement the Pennsylvania State mushroom growers received a greater share of the aid because they are closer to the two centers for research and the 200 other U. S. growers are widely distributed. Some considerable improvement is needed to bring the extension message to these non-Pennsylvania mushroom growers.

Research objectives in the past have emphasized practical aspects of mushroom culture. It is only recently that the marketing aspects of mushroom production have been studied. Basic research that would lead to new breakthroughs is much needed. Little is known about the basic physiology and genetics of mushrooms and about the ecology of mushroom substrate. There are many hundreds of species of fungi that may have economic potential but information is lacking on the methodology of growing these fungal species. Research on the other fungal species will likely lead to new food products, new drugs, new chemicals, and new flavor compounds. With the need to grow greater amounts of foods in less space, mushrooms seem ideal for this end. With the considerable quantity of solid waste that is created by our cities the mushroom could be a means of utilizing this material.

The consumption of mushrooms has gradually increased to a pound per year per person in the United States. However, the per capita consumption is several times higher in some other countries in the world and it is generally recognized that mushroom consumption in the United States will greatly increase with better marketing practices. The mushroom is a delicious and nutritive, low calorie food that fits very well into the modern American concept of diet and prepackaged foods. Thirty percent of the U.S. mushrooms are marketed fresh, 45 percent canned, 20 percent as soups, gravies, and sauces, and about 5 percent frozen, dried, or in other ways.

In the past few years mushroom exports from Taiwan to the U. S. have risen from nothing to about 17 million pounds of canned mushrooms in 1967. South Korea is entering the mushroom export market and has the climate and labor to become a major mushroom export country. The imported mushrooms from Taiwan have greatly affected the U. S. mushroom growers and this problem requires that the American mushroom industry develop better growing methods than those currently in operation. This means that a greater research effort is required in all areas of the Task Force Assignment, particularly in those that will reduce production costs.

Recommendation 1: The Task Force recommends a regional approach to extension and research programs in mushroom science. Because of the high cost of establishing research and operating facilities and the need to have a team of researchers that have available production facilities for growing mushrooms under controlled conditions, the Task Force recognizes a need for approximately four regional mushroom research centers. Each of these centers would have prime responsibility for its region. The present facilities at the Pennsylvania State University could serve Pennsylvania and nearby areas in Delaware. The station at Beltsville could serve the rest of the northeastern and the southern states because the excellent air transport facilities in Washington would allow easy travel to New York, Boston, the South, etc. New mushroom research stations are recommended for the Midwest and the West Coast. An alternative solution would be to close the Beltsville project and to move the Federal station to University Park and have only one center in the eastern USA.

At these stations mushroom growing facilities would be required for research, demonstration, and teaching purposes. A minimum staff of four full man year research appointments will be required at each station. Also, a regional extension program should operate out of each station. Five man year extension workers will be needed by 1977 and at least a half-time extension appointment will be needed at each station.

Recommendation 2: Technical training programs and graduate programs to train mushroom technical workers and new researchers need to be established and expanded. Also, special workshops and demonstration projects need to be developed and/or expanded to encourage mushroom growers to adopt improved methods.

Recommendation 3: A general expansion of research efforts is greatly needed and additional mushroom research centers are needed to provide more scientific information on mushroom science and to provide diverse and original ideas that are needed to advance the knowledge in this field. Research is needed to develop mechanical methods of growing and harvesting the crop. Also, basic research is needed on mushroom physiology and genetics and compost ecology to really break loose factors that limit production. Increased marketing research is needed to insure orderly development of the market and reduce the problem caused by influxes of foreign mushrooms into the American market. General expansion of research is required because mushrooms provide a possible means of using solid wastes for food production and other possible ways of enriching the world's supply of food. In addition, the technology of mushroom science could be used and should be used to develop other fungi for food, drugs, and chemical uses. In 1967, a total of 6 full-time researchers were employed by the USDA and SAES institutions. It is recommended that this number be expanded to 26 in 1972 and 33 in 1977.

CONTROL OF ANIMAL PESTS OF THE MUSHROOM CROP

RPA 207

Situation: Phorid, sciarid, and cecid flies, pyemotid, tarsonemid, gamasiform, and other mycetophagous mites, and nematodes of several species are the most important animal pests of the commercial mushroom crop. In addition to feeding on the mycellium and fruiting bodies of mushrooms and contaminating mushroom products, these animal pests play an important role in transporting and establishing pathogens that cause diseases of the mushroom crop. Effective control of these pests is difficult, because mushrooms are very susceptible to pesticide injury and because it is very difficult to apply pesticides under the conditions present in most existing mushroom farms.

Certain aspects of mushroom production encourages the breeding of flies and other pests, i.e. manure storage areas, run-off areas for composting yards, and the disposal of used compost. Mushroom pests breed in areas polluted by mushroom wastes and enter homes and other structures in the vicinity of the mushroom farms, creating both nuisance and health hazards to local residents. The effective control of mushrooms animal pests entering homes, etc., requires that special studies of solid wastes disposal and programs of cooperation with local health departments be established. Because many mushroom farms are being encroached upon by urbanization, mushroom growers must improve their pest control so as to be good neighbors and not to run amuck of zoning boards when requesting building permits for expanding their operations.

Objective: To fully determine the animal pest problem in the mushroom industry, to reduce damage and losses due to animals, and to develop control programs so that the mushroom industry presents no animal pest problems to the community at large.

Research Approaches:

1. To determine the species identification and life history of all of the animal pests associated with the mushroom crop. Also, to conduct a survey of all insects, mites, etc., associated with wild fungi in order to anticipate future pests and pests of new fungal crops.

2. To develop community programs of pest sanitation so that the chances of animal pest infestation is greatly reduced to the mushroom crop and to residents living in the vicinity of mushroom farms.

3. To reduce disease and animal pest damage to the mushroom crop so that the grower can produce more higher quality mushrooms at less cost and with less hazard due to chemical pesticides.

Potential Benefits: Better yields and better quality mushrooms will allow the mushroom grower to operate more profitably. Also, better animal pest control at the community level will allow the mushroom industry to expand with less hazards to neighbors and less chance of pest problems developing on the mushroom farms themselves. Losses caused by animals are serious. The mushroom is easily damaged by chemicals, making control with chemical pesticides difficult. The current production methods of the mushroom industry contributes to community fly and mosquito problems. Without improved pest control the grower will suffer heavy losses due to pests and pesticide damage and will find it difficult to expand, because of restrictions placed on him by zoning and other regulations.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.4	1	2

THE PATHOLOGY AND CONTROL OF DISEASES OF THE MUSHROOM CROP

RPA 208

Situation: A considerable number of disease problems affect both yields and quality of the mushroom crop during production. Other organisms decrease the shelf life of mushrooms at retail outlets. The etiology and epidemiology of most of these diseases are poorly understood and in some cases the causal agents are not known. It is very difficult to control diseases with only a minimum of information about the biology of the pathogens. As production levels increase and the periods between crops decrease, diseases become more difficult to prevent and control than ever before. If the mushroom grower is to provide the American consumer with the highest quality products, a number of serious pathological problems of the commercial mushroom must be solved.

Objectives: To determine the pathogenic, parasitic, or symbiotic relationships between the commercial mushroom and its competitors by establishing parameters of disease expression; the etiology of specific diseases; determining the relationship of causal agents to various ecosystems and ultimate disease expression; to define the effects of the physical environment on disease development; and finally, develop new techniques of disease control while improving present control practices.

Research Approaches:

1. Study each disease as it is affected by time of inoculation, amount of inoculum, environment around the host, the physiological condition of the host both before and after inoculation, susceptibility of the host, and the interaction of the host with the normal biotic community of the substrate.

2. The etiology of various disease causing organisms can be studied by establishing their growth response on different substrates and in different environments, their rate of reproduction, and their competitive capabilities in various ecosystems.

3. Epidemiological investigations should lead to a better understanding of the factors that affect the increase of disease. This information coupled with the development of more efficient chemical control materials will markedly reduce the loss in quantity and quality of the mushroom crop.

4. A definition of the various viruses which may be present in the commercial mushroom crop of the United States along with their effects individually and in all possible combinations.

5. A greater knowledge of the environmental and pathological factors associated with production that later affect shelf life of mushrooms may prolong the usability and desirability of fresh mushrooms.

Potential Benefits: A better understanding of the disease problems of the commercial mushroom would result in greater productivity and higher quality crops through better disease control. Losses due to disease reduce mushroom yields by an estimated 20 percent. Better control would considerably reduce these losses and decrease risks of capital and labor that smaller growers cannot affort to take.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	1.5	3	4

CONTROL OF OTHER HAZARDS ASSOCIATED WITH THE MUSHROOM INDUSTRY

RPA 209

Situation: Air and water pollution problems caused by the mushroom industry may present a hazard to people that live in adjoining areas and reduce the value of the landscape. With the urbanization of once rural areas where mushrooms are grown, there are presently serious problems because the new residents object to the presence of the odors, flies, mosquitoes, and stream pollution which they blame on the mushroom industry. While in some cases the mushroom industry is not entirely at fault, there is no question that some mushroom canners empty wash water and other wastes into streams, that many composting yards have odor and run-off problems, and that fly and pest control in composting areas is not always ideal. Also, certain weed molds associated with mushrooms cause lung diseases that are hazardous to mushroom workers.

Objective: To reduce or to eliminate air and water pollution problems created by the mushroom industry.

Research Approaches:

1. To establish cooperative research programs with health departments to establish the extent of the hazards and to then, through cooperation with chemical departments, engineering departments, etc., attempt to eliminate the pollution problems.

2. To conduct a definitive medical study of the health problem of mushroom workers.

Potential Benefits: A contribution to improved pollution control and improved working conditions for mushroom growers. Unless the mushroom industry makes considerable strides in reducing its pollution problems and unless more is known about some of the hazards associated with molds and lung diseases of mushroom growers, local, state and federal health officials may restrict or otherwise impede future expansion of the mushroom industry.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	0	1	1

IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF MUSHROOMS

RPA 307A

Situation: The genetic background of the cultivated mushroom is at the very best only partially understood. No method has yet been devised whereby a mating can be measured. In commercial production, although there are reports of varying resistance to diseases in strains, actual controlled tests have not been made. The lack of knowledge concerning the genetics of the organism has hampered efforts in the production of disease resistant strains.

Objective: To determine the feasibility of producing disease resistant strains of mushrooms through genetic recombination of characters.

Research Approaches:

1. To develop methods of laboratory testing for disease resistance by attempting fruiting in aseptic culture, and measurement of interaction on various media.

2. Single spore isolation to show heritability of differences in susceptibility of various strains to disease.

Potential Benefits: Work on disease resistance could put the mushroom industry on a comparable basis with other economic cultivated crops. The control of *Verticillium* alone could probably increase sales by ten percent.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	1	1	2

NUTRITION OF COMMERCIAL MUSHROOMS AND ECOLOGY OF THE GROWING SUBSTRATE

RPA 307B

Situation: All mushroom growing has depended on a composted material. Much research is required to determine the nature of the complex biological and chemical decomposition of this process. The specific nutrients utilized by the mushroom from this compost are also not known.

Objective: To improve the medium from which the mushroom derives its food, the compost.

Research Approaches:

1. Investigate the effects of the addition of supplementary nutrients during composting and the mushroom growth cycle.

2. Learn the optimum environmental conditions for the decomposition process.

3. Evaluate various waste products as possible new sources of basic compost ingredients.

Potential Benefits: Reduce the cost of production by increasing as well as regulating yield and quality of mushrooms obtained per unit of compost. Due to increasing competition from cheap imports, the reduction in cost of production by domestic growers as a result of procedures outlined above will be of immeasurable value.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.75	3	4

PHYSIOLOGY OF FRUITING IN COMMERCIAL MUSHROOMS

RPA 307C

Situation: Since the very beginnings of commercial mushroom production, the mycelium-impregnated compost has been covered with a layer of soil to induce the formation of sporocarps. The exact function of this casing layer has never been proven experimentally. Little is known about the effects of various properties of, management practices of, and gaseous substances accumulated in the casing layer on the formation and development of sporocarps.

Objective: To determine the effect of the casing layer on fruiting.

Research Approaches:

1. Develop a system for mushroom production whereby basis studies of life processes such as respiration can be performed during the entire growth cycles.

2. Evaluate properties of the casing layer and their effect on sporocarp initiation and production through the use of natural and synthetic casing materials.

3. Study the influence of volatile substances on growth and fruitification of the mushroom in a controlled production system.

Potential Benefits: Increase the biological efficiency of production of mushrooms. Better regulation of quantity and quality of mushrooms through an understanding of the fruiting mechanism. Development of synthetic casing media for better production. With a clearer understanding of the basic fruiting mechanisms of mushrooms, controlled product and mechanically harvesting would be possible and in addition, possible increases in yields.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.25	2	2

MECHANIZATION OF MUSHROOM PRODUCTION

RPA 308

Situation: The production of mushrooms requires extensive hand labor and tedious attention to numerous details of production such as compost preparation, spawning, soil sterilization, ventilation, hand picking, etc. Limited equipment, and in most cases no equipment, is available for mechanization of the essential operations. Therefore, hand labor has been used for operations that could be mechanized. Some jobs occur at high temperatures and atmospheric conditions that are unsafe for human workers. In recent years the life of the industry has been threatened by imports from far east countries and others where the labor rate is as low as five to fifteen cents per hour. These countries already hold from 1/2 to 1/3 of the domestic market and therefore can regulate prices. Therefore, the American industry can meet the competition only by intensive and immediate mechanization to reduce their labor per pound of mushrooms produced.

Objective: To design, develop, and evaluate methods and machines for reducing the labor per unit of mushrooms produced and also to develop mechanization for improving biological efficiency.

Research Approaches:

1. Determine the optimal environmental conditions necessary to give maximum yield responses for various cultural practices and develop control systems that can regulate the environmental parameters to produce these conditions.

2. Develop machines which would automatically perform the essential operations for mushroom production with minimum labor.

3. Develop machines and methods to mechanically harvest the mushrooms.

4. Determine the fundamental engineering properties (Thermal, electrical, optical, physical, etc.) of the various materials involved in mushroom production such as compost, spawn, casing soil, and mushroom tissue. This data will provide the foundation upon which new machines and biological processes can be developed.

5. Evaluate the potential and impact of various mechanical machines on the competitiveness of mushroom production using the techniques of engineering systems analysis and operations research.

6. Coordinate research on a national and international basis to assure that programs complement each other without duplication.

Potential Benefits: The survival of the American mushroom industry is at stake. If sufficient mechanization can be developed quick enough and adopted by the industry, they will be able to compete with the extremely low wage rates of foreign competitors.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.4	4	6

SYSTEMS ANALYSIS FOR MUSHROOM PRODUCTION

RPA 309

Situation: The mushroom industry will face increasing complex choices in the years ahead in the fields of production, processing, and marketing. The proper selection from these new alternatives that are evolving and will be evolving from research must be evaluated to provide optimum use of labor, equipment, and capital. Mathematical models with adequate record keeping services must help the mushoom industry to choose between the various alternatives.

Objectives: To develop a set of practices that meet the times, that will optimize income, and will be adaptable to change.

Research Approaches:

1. To develop uniform and precise record keeping methods for the mushroom industry.

2. Adapt, develop, and test mathematical models of mushroom production systems.

Potential Benefits: Reduced unit costs of producing mushrooms. The U. S. grower would be better equipped to compete with the rest of the mushroom growers in the world because of reduced unit production costs.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.2	2	2

PRODUCTION OF MUSHROOMS WITH IMPROVED QUALITY

RPA 405

Situation: Quality problems in mushroom production relate to pests, disease, storage, handling and the innate characteristic of the mushroom. The major problem with mushrooms is their short shelf lives. This means that food stores have low inventories of fresh mushrooms which they must rapidly sell before they suffer losses due to spoilage. The low inventories mean that stores are often without mushroom for sale or try to get rid of low quality mushrooms to prevent a total loss. Both of these actions in the long run reduce the quantity of mushrooms that the public buys. The major improvement needed is a mushroom with a prolonged shelf life.

Objective: To develop mushroom varieties that can be shipped longer distances and stored longer fresh.

Research Approaches:

1. Determine the environmental conditions that prolong the shelf life of mushrooms.

2. Identify genetic types of mushrooms that will provide longer shelf life and other desirable quality characteristics.

Potential Benefits: Increased availability of high quality fresh mushrooms to consumers in all parts of the USA. Improved shelf life and quality should substantially increase the fresh market sales of mushrooms.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.9	2	2

NEW FUNGAL CROPS

RPA 406

Situation: At present only one species of mushroom is cultivated for commercial purposes in the USA. In other countries several additional species are cultivated, including the paddy straw and shutake mushrooms. However, there are many hundreds of species of mushrooms that have potential commercial value if they could be cultured - morels, puff-balls, sulfur mushrooms to name a few. If some of these fungal species could be cultured at a commercial level, entirely new markets could be opened up because of new flavors, new protein sources, etc. With the need for greater amounts of food from smaller land areas and with the possibility of using such wastes products on areas as garbage, sawdust, small woodlots, the development of new mushrooms or fungal foods is extremely important.

Objective: To develop culture techniques for growing mushrooms such as morels, puff-balls, sulfur mushrooms, etc. under commercial conditions.

Research Approaches:

1. To thoroughly study the field conditions under which some of the potentially important fungal species grow and fruit in nature.

2. To develop cultural techniques in the laboratory for growing species of wild fungi.

Potential Benefits: Possible new sources of foods including some outstandingly delectable ones. The potential from fungal crops is tremendous in form of quantity of food from restricted areas, the possible use of waste products for culture media and the production of a healthful and tasty food.

Recommended Research Effort:	Inventory 1967	TF Recommendation 1972	TF Recommendation 1977
	0	2	2

NEW AND IMPROVED PRODUCTS FROM THE MUSHROOM INDUSTRY

RPA 407

Situation: Mushrooms and related wild fungi represent a tremendous possibility as a source for new chemicals and drugs. Very little biochemical work has been done to determine the chemical constituents of wild species of fungi. The old herbal literature is full of accounts of the drug value of certain species of fungi, but these claims have never been satisfactorily investigated. Also, the spent compost from mushroom farms represents a large mass of organic matter that could be more usefully employed than at present. These materials are to a limited extent used in gardening, farming, etc. but other possible uses could easily be developed.

Objectives: To isolate new chemical or drug products from wild fungi, develop methods of producing and marketing these materials, and also to find new uses for mushroom wastes such as spent compost.

Research Approaches:

1. A recognized mycologist and a biochemist cooperate in a systematical survey of wild fungi to determine the chemical constituents.

2. To conduct a screening test of the pharmacological actions of chemicals isolated from wild fungi with laboratory animals.

3. To develop new methods of disposing of spent composts such as building blocks, etc.

Potential Benefits: The discovery of new chemicals and new drugs may have considerable value for disease prevention and treat ment and for new chemical products. Also, better disposal of spent composts through new uses will reduce pollution problems and reduce hazards to mushroom production from animal pests and diseases. New and important opportunities for mushroom growers to produce new products and expand their industry.

Recommended Research Effort:

	Inventory	TF Recommendation	
	1967	1972	1977
	0	1	2

DEVELOPMENT OF PROCESSING SYSTEMS FOR
THE MUSHROOM CANNING INDUSTRY

RPA 408

Situation: About three-fourths of the mushrooms grown in Pennsylvania are sold to processors. During the most recent crop year, 67 million pounds were purchased by mushroom processors. These statistics indicate the crucial significance of the mushroom processing industry to the entire mushroom industry of the state. Recent competition of low cost, imported canned mushrooms has created a serious threat to domestic mushroom processors. Imports during 1967 accounted for 35 percent of the domestic consumption. The low cost feature of imports is a reflection of the drastic differential between labor costs in domestic and foreign operations. In the USA nearly one-half of processing costs are attributed to labor. If the domestic processing industry is to survive, significant increase in efficiency of processing operations is necessary.

Objective: Development of mechanized and automated systems for the mushroom canning industry.

Research Approaches:

1. Size and quality distribution: The need for automation of the mushroom processing industry is apparent. At its present state of development the automatic cutting device requires precise sizing of the mushrooms before they can be oriented for cutting. Since each of the size classifications requires a separate module to orient and cut the stem, extensive knowledge of size and quality distribution of mushrooms by spawn strain, crop break, and other cultural practices is needed to engineer the system to the product.

2. Electronic inspection: A fully automated processing system would require some method of culling out product of inferior quality. The principle of electronic sorting is being applied in other areas and adaptation of a system for mushrooms will depend upon the light properties of mushrooms. Much preliminary data must be obtained such as light relectance properties of normal mushrooms, and of mushrooms which are diseased or have open veils.

3. The blanching operation: Mushroom shrinkage (loss in weight) remains one of the major problems confronting the processor. Most of the

shrinkage has been shown to vary with the type of blancher employed. With the advent of automated processing systems, the blanching operation must be adapted to it. The choice of blanching method to be incorporated in any future mushroom processing system will depend largely on the degree of shrinkage inherent in the method. Performance data on all types of blanchers must be obtained for mushrooms. Some data have been obtained for the thermoscrew and rotary type blanchers presently being used in the industry. These data need to be confirmed and the performance of micro-wave, tubular, and pressure blanchers must be determined for mushrooms. Fluidized bed conveying might be utilized in conjunction with one or more blanching methods to reduce the solids loss which is encountered with present methods of handling mushrooms during and after the blanch.

4. Can filling: Performance of various automatic can filling machines needs to be evaluated for mushrooms. The present methods of hand filling and use of semi-automatic equipment are inefficient and cannot be incorporated into an automated system.

5. Thermal processing: The steriflame method of cooking mushrooms in tin and glass containers needs to be evaluated critically for its effects on product quality and shrinkage. The process is fully automated and well adapted for incorporation into complete systems, but performance data for mushrooms are not available at present.

Potential Benefits: Reduction in cost of mushroom canning operation will improve the competitive position of domestic mushroom processing industry. Future success of Pennsylvania's mushroom canning industry depends largely on the development of efficient processing systems.

Recommended Research Effort:

Inventory 1967	TF Recommendation 1972	TF Recommendation 1977
.25	1	1

IMPROVEMENT OF GRADES AND STANDARDS

RPA 501

Situation: Grades and standards are necessary in the marketing of mushrooms to assure that the American product has fair competition from the imported products. One study conducted several years ago showed that imported mushrooms were 200 times higher in filth than American mushrooms. Objective, quick and accurate measurements are needed for both fresh and canned packs. Some efforts in the establishment of grades and standards have been made with American producers but almost anything goes when it comes to imports.

Objective: To provide fair grades and standards that apply to both domestic and imported mushrooms.

Research Approaches:

1. Evaluate the effectiveness of existing grades and standards in light of the consumer needs and establish methods for inspecting imported products.

2. Establish a uniform system of grades and enforce them for domestic and imported products alike.

Potential Benefits: Better quality mushrooms for the American consumer. Insufficient standards from imported mushrooms allow them to compete unfairly with domestic mushrooms and permit mushroom products that may be hazardous to the American public to market.

Recommended Research Effort:	Inventory 1967	TF Recommendation 1972	1977
	0	1	1

PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING

RPA 504

Situation: The recent expansion of mushroom production in Formosa has greatly depressed prices in the world and US mushroom markets. Other countries in Southeast Asia are planning on producing mushrooms for export within the next few years. Production and processing technology is rapidly changing in the US and European producing areas. Consumer trends are changing and the entire mushroom marketing situation is in a state of flux.

Objective: To obtain information so that the US mushroom producer and processor can plan for the future.

Research Approaches:

1. Evaluate the economic impacts of great quantities of imported mushrooms on the US markets.

2. Study prices and marketing costs, margins, practices and services.

Potential Benefits: Reduce production, processing and distribution costs of mushrooms. Data are lacking on the efficiency of mushroom production in the US but there is no question that improved information of the economics of this industry would greatly enhance the chances of the US producers competing effectively with imported mushrooms.

Recommended Research Effort:	Inventory	TF Recommendation	
	1967	1972	1977
	.25	2	2

Task Force Recommendations on Mushrooms

Summary of Recommended SMY's

	Research Problem Area	1972	1977
207	Control of Animal Pests	1	2
208	Control of Diseases	3	4
209	Control of Other Hazards	1	1
	Subtotal Protection	5	7
307	Biological Efficiency	6	8
308	Mechanization	4	6
309	Systems Analysis	2	2
405	Consumer Acceptability	2	2
	Subtotal Production	14	18
406	Food Products	2	2
407	Feed and Non-food Products	1	2
	Subtotal Utilization	3	4
408	Market Quality	1	1
501	Grades and Standard	1	1
504	Market Efficiency	2	2
	Subtotal Marketing	4	4
	GRAND TOTAL	26	33

(These SMY's are additional to the level recommended in major part of this Task Force report).